Investigating the Relationship Between FDI and the Environment in OECD Countries: A Sectoral Approach

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ABSTRACT

Over the last two or three decades increasing and ever accelerating trends of environmental degradation have been recorded and widely reported in a number of international scientific works. As is often claimed, this situation is particularly attributable to globalization and the widespread increase of economic activities. The recognition that FDI represents a relevant part of globalization raises various concerns. However, its environmental implications are not easy to identify and this gives rise to complex arguments and contradictory views.

This work aims to give a modest contribution to the scientific reflection on the FDI-environment relationship and is structured as follows. The first chapter introduces the main aspects of FDI and identifies the links characterizing its relationship with the natural environment. The second chapter provides a literature review. The third chapter is entirely dedicated to the empirical analyses which attempt to go beyond what is done in the literature. In fact, in addition to a major interest in trade, a particular orientation to develop analyses on national aggregated data is generally observed. Our work, instead - and this might be perceived as its original contribution - investigates the mentioned relationship at the level of specific activity sectors. Through the use of the econometric technique of panel data, a purpose-built dataset is investigated to mainly observe the effect that FDI inflowing in the "agriculture and fishing", the "manufacturing" and the "transport and communication" sectors of the OECD countries generates on the level of some considered pollutants. More specifically, the analysis of the "agriculture and fishing" sector focuses on both the FDI-CH_4 (over the period 1990-2005) and FDI-CO_2 from the sectoral fuel combustion (over the period 1981-2005) relationships. The "manufacturing" and "transport and communication" sectors are analysed only on the basis of the FDI-CO_2 from the sectoral fuel combustion relationship (over the period 1981-2005). Two final chapters are respectively dedicated to the concluding discussion and policy considerations of the work.

The results of our analyses, expressed in terms of cumulative effects, show that when the investigation of the "agriculture and fishing" sector is made to observe the CH_4-FDI relationship, the coefficient results equal to + 0.0427 + 0.0018 *FDI*, this showing the increase of Methane emission when FDI grows by 1%. When the "agriculture and fishing" sector is analysed in relation to the CO_2-FDI relationship, the cumulative effect coefficient becomes equal to - 0.0848 - 0.0036 *FDI*, this representing the response of CO_2 as a result of 1% growth of FDI. The cumulative effect coefficient for the "manufacturing" sector is equal to + 0.0058 + 0.0014 *FDI* which represents the increase of the sectoral CO_2 from fuel combustion when FDI grows by 1%. Finally, the coefficient of the cumulative effect for the "transport and communication" sector is found equal to + 0.0027 + 0.0014 *FDI*, this representing the growth of the sectoral CO_2 from fuel combustion as a result of a 1% increase of FDI.

If the inflow of FDI in each sector is considered at the sample mean value, then for "agriculture and fishing" an actual cumulative impact of +0.0213 is observed for the CH_4-FDI and another of -0.0436 for the CO_2-FDI relationship. An actual cumulative impact equal to +0.0051 is observed for the CO_2-FDI

relationship in the "manufacturing" sector and another of +0.0022 for the CO_2-FDI in the "transport and communication" sector[1].

Apart from the interpretation of the algebraic signs, which would make us say that FDI is beneficial to the environment when the sign of the identified effect is negative and vice-versa, it is worth underlining how a closer look at the quantitative aspect of our results would allow us to highlight the nearly-zero value and the almost neutral role that FDI exerts on the considered environmental indicators. This is also confirmed by the very small and almost quantitatively insignificant results achieved from assessing the impact FDI exerts on the considered pollutants through GDP. With regard to the "agriculture and fishing" sector, the impact of FDI on CO_2 through GDP cannot be identified due to the insignificant result achieved in the estimation of the CO_2-GDP relationship. Apart from this, however, an outcome equal to -0.0003 is observed when the impact of FDI inflowing in the "agriculture and fishing" sector on CH_4 is assessed through GDP (with FDI and GDP considered at their sample mean value respectively). Similarly, a result of +0.00002 is observed when assessing the impact of FDI on CO_2 through GDP in the manufacturing sector and another of +0.0006 when the "transport and communication" sector is made the subject of attention[2].

[1] Values expressed in natural logarithm of CO_2 in Mt.
[2] Values expressed in natural logarithm of CO_2 in Mt.

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DEDICATION

To my Children Thomas George and Emma Victoria, my Wife Claire,
my Parents and all my Family.

Thank You all for having shared the enormous sacrifice required
to develop this work. It could never have come to light
without Your Love, Understanding and Support.

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Of course, any mistakes still existing in these pages are my own responsibility.

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AEMs	= Agri-Environmental measures
ARDL	= Autoregressive Distributed Lag
BITs	= Bilateral Investment Agreements
BOD	= Biological Oxygen Demand
CAP	= Common Agricultural Policy
CEOs	= Chief Executive Officers
CEPII	= Centre d'Etudes Prospectives et d'Informations Internationales
CO_2	= Carbon Dioxide
EKC	= Environmental Kuznet’s Curve
EKC	= Environmental Kuznets’ Curve
FDI	= Direct Investment
FE	= Fixed Effects
GCF	= Gross Capital Formation
GFCF	= Gross Fixed Capital Formation
GDP	= Gross Domestic Product
Gg.	= Gigagrams
GHGs	= Greenhouse Gases
IEA	= International Environmental Agency
IF	= International Firm
IMF	= International Monetary Fund
JV	= Joint ventures
LDCs	= Less Developed Countries
M&As	= Merger and Acquisitions
MAI	= Multilateral Agreement on Investment
Mln.	= Million
Mt.	= Million tons
MNC	= Multinational Corporation
MNCs	= Multinational Corporations
Mtoe	= Million tonnes oil equivalent
N_2O	= Nitrous Oxide
NAFTA	= American Free Trade Agreement
NGOs	= Non-Governmental Organisations
NIMBY	= Not in My Backyard
NOx	= Nitrogen Oxides
ODA	= Official Development Assistance
OECD	= Organization for the Economic Cooperation and Development
OLS	= Ordinary Least Squares
pCO2	= Atmospheric Carbon dioxide
PIF	= Private International Finance
ppmv	= per million in volume
RE	= Random Effects
SO_2	= Sulfur Dioxide
TNC	= Transnational Corporation
UNCTAD	= United Nations Conference on Trade and Development
USDIA	= United States Direct Investment Abroad
WB	= World Bank

WIPS = World Investment Prospects Survey
WIR = World Investment Report
WRI = World Resources Institute

Chapter I

Introductory aspects to the analysis of FDI and its links with the natural environment

1.1. Introduction.

One of the most relevant aspects of the globalization phenomenon is represented by the dynamic of financial capital flows around the world. Although the term "international financial flow" refers to a series of forms of capital, in which Official Development Assistance (ODA)[1] and tools of the so-called Private International Finance (PIF), such as portfolio equity investment[2] and debt finance[3] are considered, it often centres on Foreign Direct Investment (FDI)[4]. The reason why most of the available literature refers to FDI lies in the fact that, as a form of private capital, it accounts for the greatest part of the PIF to emerging economies[5].

[1] ODA is represented by flows of official financing conceded with a grant element of at least 25% and administrated with the main aim of promoting economic development and welfare in developing countries. ODA flows comprise of contributions given by donor government agencies at all levels to developing countries ("bilateral ODA") and to multilateral institutions. ODA receipts comprise of disbursements by bilateral donors and multilateral institutions (OECD, 2007).

[2] Portfolio investment refers to the category of international investment that covers investment in equity and debt securities, excluding any such instruments that are classified as direct investment or reserve assets (OECD, 2007).

[3] It can be referred to either commercial loan or bonds. The first refers to loan financing to developing countries by commercial banks, export credit agencies, other official institutions in association with other agencies or banks, or the World Bank and other multilateral financial institutions. The latter refers to a debt tool that usually gives the holder the unconditional right to fixed money income or contractually determined variable money income. With the exception of perpetual bonds, it also provides the holder with an unconditional right to a fixed sum as repayment of principal on a specified date or dates. In international finance a bond can typically assume the specific form of structured bonds. These have some characteristics that are designed to attract a certain type of investor and/or take advantage of particular market circumstances.

[4] For now, we simply define FDI as investment made by a company of a country in subsidiary or joint venture firms abroad. A more detailed definition will follow in the next section.

[5] FDI is the single largest and fastest growing component of private capital flow, especially in developing economies, despite the effect of the global economic downturn of the last few years (UN, 2012; 2011). If we consider, for example, the period between the early 1980's and the early 2000's – corresponding to the time span considered in our empirical analysis which will be presented in the next sections – its inflow to Low-Income Countries (LICs) averaged only 0.2% of their GDP in the early 1980's, but rose to more than 3% by the end of 2006, showing a more than tenfold increase. The other private flows (including workers' remittances), instead, were more than triple during the same period. In fact, they rose from 1.1% of the LICs GDP in the early 1980's to 3.6% in 2006 (Dorsey, 2008). In more recent years, between 2009 and 2010, the FDI quota arriving to developing and transition economies reached more that half (53%) of global FDI flow (UNCTAD, 2012; 2011).

Its relevant and beneficial role in countries growth and development processes is generally recognized and reported in terms of job creation, introduction and spread of innovation and new technologies, transfer of intangible resources such as better practices and new methods of organization, which result in production efficiency improvements and increase in competitiveness.

However, we should also consider that FDI is characterized by a “hidden aspect”, which is not always taken into proper consideration. According to some of the last available reports of the United Nations Conference on Trade and Development (UNCTAD), it can be appreciated that FDI has always traditionally and significantly relied on the use of natural resources (especially in agriculture, mineral extraction, fuel and chemical production). Although the evolutionary dynamic of the last 20 years or more has shown a structural shift of FDI flow towards the service sector, which is generally believed to be less resource-use intensive, it can be observed that a relevant amount of FDI is still reaching developing countries and especially those sectors primarily based on the use of natural resources. Furthermore, as is provisionally referred for the years ahead, FDI flow is expected to increase in the primary sector, and particularly in the extractive industries of resource-rich countries (UNCTAD, 2007; 2004).

In addition, particularly in the last decades increasing and accelerating trends of environmental degradation have also been recorded, which are widely referred to in a number of scientific reports and studies. The global warming generated by greenhouse gas emissions seems to be just the synthesis of a variegated series of environmental problems, which range from deforestation and biodiversity loss to ice melting and the change in sea levels (UNEP, 2007). As is generally recognized and claimed, these patterns of environmental degradation are also the result of widespread economic activities worldwide. The recognition that FDI relevantly contributes to this dynamic raises some concerns on the effects associated to the FDI phenomenon and, particularly, on its environmental effects, whose identification is of crucial importance in identifying and implementing appropriate governmental policies. In fact, whether FDI is really functional for development and, in particular, for sustainable development, depends especially on the way it is managed by the receiving countries’ governments. In other words, it depends on their vision of economic development and environmental conservation management that is on their policy and regulatory frameworks. However, the identification of the environmental implications resulting from FDI movement – and more broadly from the transfer of international capital flows – to other countries and particularly to developing areas is not easy and gives rise to complex arguments and contradictory perceptions and views.

On the one hand, for example, investors – especially those who move resource-seeking FDI – basically find their motivation in searching for those countries which can ensure the highest level of economic returns. As is quite often perceived and sometimes observed, these countries are normally those having a relevant endowment of natural resources and a feeble or ineffective environmental regulatory framework (UNCTAD, 2007; 2004). Such a condition potentially represents a high threat for the local communities and the natural environment upon which their lives rely[6]. It is also perceived and observed that countries' economic growth induced by international investment is often accompanied by "industrialized countries' style" or "western-style" consumerism, which can potentially represent a further contribution to worsen the equilibrium of the world's natural system, the earth's climate conditions and the security of food supply as a result[7].

On the other hand, international investment is also felt to bring benefits to the natural environment. In particular, the FDI movement from developed to developing countries can facilitate the transfer of more modern technologies, which guarantee a greater efficiency in the use of natural resources and energy, together with the minimization of waste and residuals from the production process. If this is the case, developing countries might avoid some of the more damaging phases of the industrialization process well known to those

[6] With regard to this, let us think of situations such as, either the implementation of a large construction project which displaces local people from their territory, or those cases, especially observable in the area of the Amazon forest in Brazil and in various other African countries, where indigenous communities defencelessly watch the change and disappearance of their homelands as a result of timber companies' activities.

[7] In this perspective, international investment can also lead to a lifestyle change for local communities, which might begin to express preferences for the consumption of industrial polluting goods such as cars, paper, plastic, etc. As a result of this situation, there is an increase in industrial activity and in turn a growth in pollution emissions.

industrialized countries which are still bearing the clean up cost of their natural environmental systems.

However, it seems that the environmental reflection within the FDI issue has generally suffered from a lack of adequate attention and has often been left aside and unconsidered[8]. For example, in analysing the rapidly increasing dynamic of the international capital flow towards Asia since the beginning of the 1990's, and its reversed course following the economic crisis recorded in the region during the second half of that decade, commentators and experts referred to the outgrowth of those countries' financial regulatory structure as a main explanation. Only a few people paid attention to the other critical aspect represented by the relationship between international capital flow and the environment. Their aim was to understand the extent to which the huge amount of international finance flown to the countries of that developing region destabilized the ecological foundations of these emerging economies (i.e. Shahbaz et Al., 2011; French, 1998).

As will be reported later in the chapter analyzing the literature review on the relationship between FDI and the environment, much of the current debate focuses on the conditions characterizing the process of FDI location decision, the resulting competition between countries for FDI and how this effects environmental standards and regulations. Among the various aspects the literature considers within this field of argument, the "pollution havens" hypothesis seems to be the most investigated. Very briefly, this hypothesis states that FDI moves to

[8] It is worth highlighting at this point that very often the literature discusses more the environmental effects of globalization, while referring to the relationship between trade – rather than FDI – and the environment. As is generally observed, the existence of a link between FDI and trade exists and is based on their relationship of either complementariness or substitutability. On the one hand, according to the earlier view, the shrink of trade barriers promotes the growth of trade and FDI. On the other hand, evidence of an inverse FDI-trade relationship exists. The debate refers to factor proportion differences, protectionist behaviours, and proximity-concentration trade-off of countries as main aspects influencing this dichotomy. Empirical evidence varies a lot depending on the qualification of sample and proxies used, thus showing huge difficulty in finding a generally valid pattern in the FDI-trade link (Michi et Al., 2006; Michi et Al. 2005). Having said this, we highlight how the issue of trade goes well beyond the scope of our work. For this reason, we do not go any further in its analysis. However, where possible and retained useful, the aspect of trade – in the form of the various proxies it can assume – will be taken into consideration in the next chapters where the empirical tasks are reported. In agreement with other works, in fact, FDI does not occur in a vacuum and the decomposition of its relationship with the environment into scale, structural and technology effects – as they will be explained later in this chapter – would be very difficult without considering the FDI links with other aspects among which trade appears to be one of the most relevant (OECD, 2002).

those countries where more lenient environmental regulations offer the advantage of producing at a lower cost. As a result, countries may compete for FDI, thus getting involved in a “race to the bottom”, which is a further hypothesis occurring when countries intentionally undervalue their environmental assets and lower the stringency of their environmental regulations with the aim of bringing in FDI, thus generating an increase in pollution and environmental degradation. As will be referred later in the appropriate section, however, empirical studies have been and are still unable to systematically prove the existence of the various hypotheses, thus the achievement of a universally accepted conclusion is still missing. Among the various difficulties occurring in the identification of the above considered aspects, the use of aggregate data of investment flows, the excessive focus on site-specific environmental impact and the consideration of emissions related to a few industrial pollutants are the most relevant. However, there is plenty of evidence that pollution-intensive industries do have location preferences for low environmental standards and are able to influence governments to create lenient environmental regulations (WWF, 2001).

As a result of the difficulty to empirically investigate the very complex and dynamic interaction between increasingly mobile production and environmental regulation, some feeling that the “pollution havens” hypothesis debate has generated a policy stasis, by attempting to pursue indemonstrable evidence, exist. Indeed, it seems that the excessive focus on this hypothesis has driven the discussion on FDI-environment relationship away from what could be perceived as other more relevant questions such as, for example, the identification of more specific linkages between FDI-induced development and the environment, the regulatory capacity and the environmental limits within which economic activities can take place, and the planning of resource use.

Having said this, FDI is still widely and convincingly thought to be beneficial for societies and their natural environments, this being an incentive for negotiators and policy decision-makers to support the pointlessness of setting up environmental restrictions in international investment agreements. However, it must be avoided that FDI-induced economic growth is achieved at the expense of societies and their natural environment. For this reason, a call for better management and governance of FDI should be on the agenda of institutions and scientific research with the aim of identifying methods and ways of making FDI really work for sustainable development.

While keeping in mind that the main objective of this work is to contribute to the reflection on the FDI-environment relationship by the identification of more specific links between these two aspects, in this chapter we begin to focus our attention on representing and explaining the introductory and main aspects of the FDI phenomenon. To this purpose, its definition, main qualitative features, measures and effects will be the subject of the next section. The following part will be dedicated to the analysis of recent trends and prospects of FDI. A final paragraph will briefly comment on and conclude the arguments highlighted in the chapter.

1.2. Definition and categorization of FDI.

According to the definition given by the UNCTAD, "FDI is an investment involving a long-term relationship and reflecting a lasting interest and control by a resident entity in a given economy (foreign direct investor or parent enterprise) in an enterprise resident in an economy other than that of the foreign direct investor (FDI enterprise or affiliate enterprise or foreign affiliate)" (UNCTAD, 2007: 245)[9]. As can be observed, two keywords represent the main feature characterizing the definition: lasting interest and control. In fact, a FDI is normally distinguished by the other form of private capital, and particularly from the portfolio equity investment, because it implies long term investment relationship while the latter results more volatile. With regard to the second feature of control, the identification of a FDI by general convention occurs when a minimum of 10% shareholding in a foreign firm's capital is considered.

[9] Other definitions are provided by the International Monetary Fund (IMF) and the Organization for the Economic Cooperation and Development (OECD). The IMF defines FDI as an investment made to acquire a *lasting interest* in an enterprise operating in an economy other than that of the investor, the investor's purpose being that of having an effective voice in the management of the enterprise (IMF, 1993: 93). The OECD defines FDI as the category of international investment that reflects the objective of a resident entity in one economy to obtain a lasting interest in an enterprise resident in another economy. Although all these definitions are slightly different from that given by the UNCTAD, they do not show significant changes especially with regard to the basic features of FDI.

FDI is an activity which is normally run by Multinational Corporations (MNCs). In fact, the literature generally refers to MNCs as those firms which undertake FDI as the main motivation of their activity. No single definition of what a MNC exists. However, a basic distinction is usually made between International Firm (IF), Multinational Corporation (MNC) and Transnational Corporation (TNC)[10].

The actual implementation of FDI may take either the form of greenfield investment, or the form of cross-borders Merger and Acquisitions (M&As), or the form of joint ventures (JV). By definition, the first form refers to an investment made "from scratch", aimed at creating a completely new enterprise in host territorial areas where no previous production, distribution or other facilities exist. This type of investment can be very costly for the investor, but it is often gladly accepted by host countries, because of its high job-creation potential and its relevant capability to increase the value-added of the host country's production. As the name implies, M&As are typically implemented via the ownership change of existing enterprises. It specifically refers to investment dealing with the buying, selling and combining of companies. This mode of investment has the advantage of being cheaper than greenfield investment and gives the investor quick access to the market of the host country. Lastly, JV investment is made by a foreign firm under an agreement with one or more firms or government institutions in the host country, as well as other companies outside the host country. All parts in the agreement are committed to bringing their own skills and expertise to the investment operation such as, for example, the knowledge of the local or national market and bureaucracy, technical and financial capabilities, etc. (Moosa, 2002).

The classification of FDI typically distinguishes the operational view of the source country of the investment from that of the host country. From the view of the source country, or the investor's view, FDI can be categorized in horizontal, vertical and conglomerate. Horizontal FDI refers to an investment operation

[10] An international firm can be defined as a firm which works in importing and exporting goods produced in the domestic market and then exported abroad and vice versa. The evolution of an international firm can bring to the identification of a multinational firm, which refers to a firm producing both at home and abroad (through subsidiaries, affiliates and joint ventures). The further evolution of the firm can identify the transnational corporation. This occurs when a firm evolves at such a point that difficulties arise as to the identification of its home country (Moosa, 2002).

aimed at the horizontal expansion of the production. This means that an investor, operating in the source country, decides to produce abroad – in a country which will host the investment – the same or a similar type of product he produces at home with the aim of expanding his market opportunity. What characterizes horizontal FDI is the lack of product differentiation between that produced at home and that in the host country. This kind of investment is typically run to exploit the advantage of a certain power position in the market (i.e. monopoly or oligopoly) a firm derives from holding, for example, patents and where the expansion in the home country may contravene anti-trust regulations. Vertical FDI is, instead, undertaken with the aim of gaining the economic advantages that an investor derives from a better management of his organizational chain. In fact, he may consider it advantageous to be as close as possible to the market of raw materials acquisition and/or to final consumers. The earlier case may occur through investment to buy other firms working as raw materials suppliers (backward vertical FDI). The latter may take place through the acquirement of distribution outlets (forward vertical FDI). Lastly and very simply, conglomerate FDI represents a mix of the previous two types (Moosa, 2002).

From the view of the host country, FDI can be categorized into import-substituting, export-increasing and government-initiated FDI. Import-substituting FDI is basically determined by aspects such as the market size of the host country and the existence of transportation costs and/or trade barriers. It refers to an investment which enables the host country to become producer of certain products which were previously imported. As a consequential result, imports by the host country, but also exports by the source country, will decline with a potentially realistic improvement of the balance of payments of the earlier. Export-increasing FDI occurs when a country becomes object of interest of an investor, who seeks further or new sources of input factors. In such a case, the host country increases its export of certain products (normally raw material and/or intermediate goods) to the investor's country and/or other countries where his subsidiaries are located. Government-initiated FDI refers to that form of investment which is stimulated by the provision of forms of incentives offered by governments to attract investment in the attempt to improve their balance of payments conditions.

A possible last classification of FDI distinguishes between expansionary and defensive FDI. Expansionary FDI is a form of investment which is aimed at the exploitation of firm-specific advantages (e.g. scale effects, R&D intensity, profitability and technology acquisition, etc.) in the host country and has the additional benefit of contributing to the growth of sales of the investing firm both at home and abroad. Defensive FDI is that investment which is aimed at reducing production costs and, in doing so, seeks cheap labour (or other cheap input factors) in the host economy (Chen & Ku, 2000; Chen & Yang, 1999).

1.3. Measures and effects of FDI.

With regard to the quantitative aspect of FDI, it can be observed how its measure is generally expressed either in terms of flow or in terms of stock. FDI flows include the capital invested – either directly or indirectly through related enterprises – by a foreign investor in an enterprise, or the capital received from an enterprise by a foreign investor. More specifically, "for associates and subsidiaries, FDI flows consist of the net sales of shares and loans (including non-cash acquisitions made against equipment, manufacturing rights, etc.) to the parent company plus the parent firm´s share of the affiliate´s reinvested earnings plus total net intra-company loans (short- and long-term) provided by the parent company. For branches, FDI flows consist of the increase in reinvested earnings plus the net increase in funds received from the foreign direct investor. FDI flows with a negative sign (reverse flows) indicate that at least one of the components in the above definition is negative and not offset by positive amounts of the remaining components". With regard to FDI stocks, we can learn how "for associate and subsidiary enterprises it represents the value of the share of their capital and reserves (including retained profits) attributable to the parent enterprise (this is equal to total assets minus total liabilities), plus the net indebtedness of the associate or subsidiary to the parent firm" (UNCTAD, 2007)[11]. Furthermore, it is important to highlight how FDI flow and stock may take the form of inward or outward investment depending on the direction it takes.

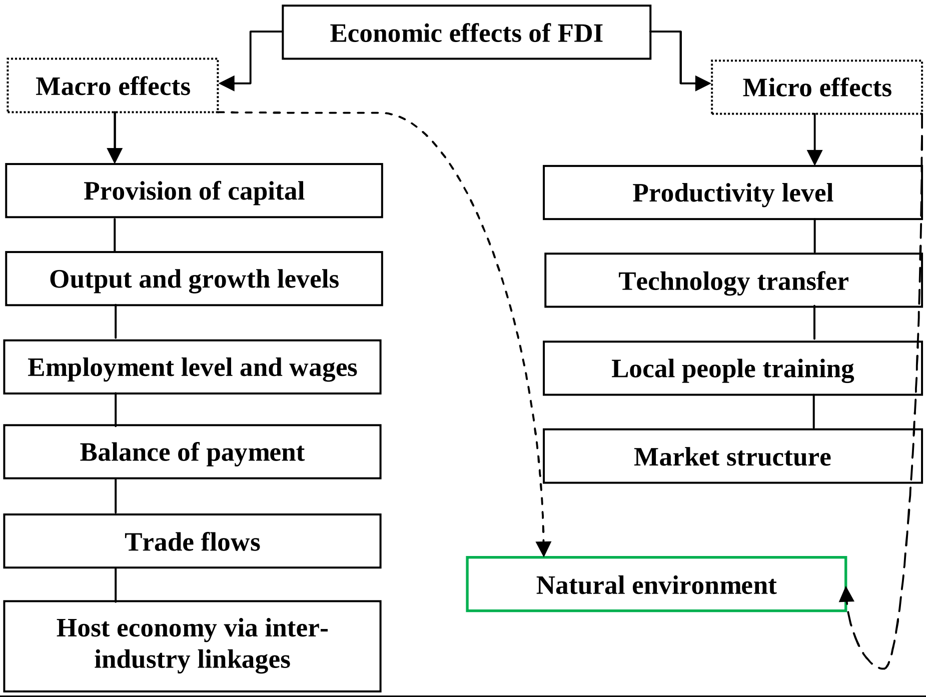
[11] These definitions are gathered from the UNCTAD web-page in the source and definition section available at http://unctad.org/en/Pages/DIAE/FDI%20Statistics/Sources-and-definitions.aspx.

Very simply, FDI flow or stock is inward when an investor of a foreign country invests in a considered country. It is outward when an investor from a home country invests abroad (Moosa, 2002).

According to Cantwell & Bellak (1998), it is generally referred that the practice of reporting FDI in terms of stock is basically unsatisfactory. Stocks are expressed in terms of their "book value", namely their historical cost, which does not take into consideration their age distribution and makes international comparison almost impossible. Apart from this specific aspect, we must understand that measuring FDI is not straightforward because of the existence of problems especially occurring when the investment takes the form of machinery or contributions of technological capitalization. Furthermore, due to the reluctance of most countries to provide comprehensive information on the foreign operations of their companies for reasons of secrecy, gaps exist in FDI statistics available for source and host countries (Moosa, 2002).

After having talked about the quantitative dimension of FDI and clarified some basic aspects of it, we can now move onto giving a broad look at the effects it generates. The FDI dynamic involves the transfer of various elements (financial capital, technology, labour skills, etc.) from a country (the source of the investment) to another (the destination or recipient of the investment). This process implies the rise of costs and benefits for the countries involved. Due to the existence of a general disagreement – based on the existence of different views pro and con the globalization phenomenon – it is not really clear what costs are endured and what benefits are gained by the countries. This is particularly true from a quantitative view. However, the FDI effects issue is basically treated from the host country's point of view. According to the review by Moosa (2002), the effects of FDI on an investment host country can be of the following type: economic, political and social. In short, the social issue mainly concerns the creation of enclaves and foreign elite in the host country, as well as cultural and behavioral changes as a consequence of a sort of "contamination" resulting from the contact between the foreign and local entities. The political effects refer to the question of national sovereignty. It is natural to think that – and this could be particularly true in Less Developed Countries (LDCs) – because of the relevance of the interests implicated by the management of a MNC, a threat for the national political autonomy of the host country could exist. The economic effects are distinguished in macro and micro effects as shown in the scheme below.

Graph 1.1 – Economic effects of FDI.



Source: built and adapted from Moosa's (2002) discussion.

The earlier are often referred to in the same terms as a rise in foreign borrowing. If there is unemployment and capital shortage – that is the typical case of LDCs – FDI (which is provision of capital) leads to an increase of output and income together with a reduction of unemployment in the host country. In this sense FDI has a beneficial effect on the balance of payment, but its effect in terms of trade is indeterminate since this will depend on whether the impact of increased output falls on import substitutes of export. The micro effects, instead, concerns structural changes in the economic and industrial organization. Broadly speaking, they refer to individual firms and individual industries, particularly those exposed and associated with FDI. Within this context, for example, a relevant argument is whether FDI leads to a more competitive economic environment.

It must be highlighted, however, that the issue of the economic effects of FDI has very often failed to consider those associated to the natural environment. At least this is true up to the late 1990's when the sensitivity for this specific aspect began to appear in the reports of some international organizations. We have inserted the environmental component in the figure above as an adaptation of the discussion of the already-mentioned author, who has the merit of having summarized the state of art of the literature previously produced. The issue of the FDI-environment relationship is the argument we are going to pay attention to in the further development of this work.

1.4. Recent trends and prospects in the FDI dynamic.

In this section we examine some recent trends and prospects in FDI by reporting the information dispatched by the UNCTAD. More details on the global and regional trends and prospects of the FDI dynamic can be found in its World Investment Report (WIR) series, which – at the time of writing – shows the WIR 2012 as the last available update. Grasping information from the UNCTAD statistical database – which is synthesized in tables 1.1 and 1.2[12] – and the mentioned investment report, it is possible to observe how the global FDI inflow significantly increased between 2002 and 2007 moving from about 627,975 million US$ in 2002 to 1,975,537 million US$ in 2007. In 2008 and 2009, the flow decreased as a result of the global economic turmoil. However, despite the financial and economic crisis of these two years and the ongoing sovereign debt crisis, the global inflow of FDI increased by 16% between 2010 and 2011. More specifically, it rose from about 1,309,001 million US$ to about 1,524,422 million US$ showing an ameliorated situation with respect to what could be observed at the pre-crisis average level recorded between 2005 and 2007.

[12] Here our discussion only focuses on the flow of FDI for the reason already stated in the previous sections. In order to present a complete picture, however, we also report tables 1.3 and 1.4 to illustrate FDI stock data but we do not proceed to comment on it since - as can be easily observed - its trend basically replicates that performed by the FDI flow.

Tab. 1.1 – *FDI inflow and outflow in considered regions in 2002-2011.*

Region/Country	1981-2001*	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Inward flows (in million US$ at current prices and current exchange rate)										
World	339479,1	627974,8	586956,4	744329,2	980727,1	1463351,2	1975537,0	1790705,7	1197823,7	1309001,3	1524422,2
Developed economies	248194,3	443431,7	376807,6	422179,1	622625,4	981869,3	1310425,4	1019648,0	606212,3	618586,1	747860,0
Developing economies	88389,8	173283,0	190124,8	291866,0	327247,8	427163,4	574311,5	650016,8	519225,0	616660,7	684399,3
Transition economies	2895,0	11260,1	20023,9	30284,1	30854,0	54318,4	90800,1	121040,9	72386,4	73754,5	92162,9
Total OECD	274699,3	205046,7	186699,8	222196,6	231225,9	366368,8	586850,3	693359,0	841108,7	875218,3	621441,6
European Union	140845,7	312003,1	274292,2	225900,9	499375,5	585030,2	853965,6	542242,4	356631,5	318277,4	420715,2
	Outward flows (in million US$ at current prices and current exchange rates)										
World	335525,8	528495,9	570679,3	925716,1	888560,8	1415093,9	2198025,0	1969336,0	1175108,4	1451364,7	1694396,1
Developed economies	300221,0	476341,0	513209,9	788795,1	741744,2	1152033,6	1829578,1	1580752,9	857792,0	989576,4	1237507,6
Developing economies	34468,5	47484,3	46667,6	122791,6	132507,0	239336,0	316863,5	328120,8	268476,0	400144,1	383753,7
Transition economies	836,3	4670,6	10801,8	14129,5	14309,6	23724,3	51583,5	60462,3	48840,4	61644,2	73134,8
Total OECD	300529,1	2271189,4	2449861,2	3935539,2	3653673,3	5716725,8	9177470,3	7892658,6	4611633,2	5556892,5	6688833,9
European Union	187510,5	259864,4	290173,3	371478,0	604075,6	691763,9	1204747,4	957797,6	393618,3	482904,6	561805,0

** annual average;*

Source: UNCTADstat.

Tab. 1.2 – *FDI inflow and outflow in considered regions in 2002-2011 (% of the total).*

Region/Country	1981-2001*	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Inward flows (in %)										
World	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**
Developed Economies	73,1	70,6	64,2	56,7	63,5	67,1	66,3	56,9	50,6	47,3	49,1
Developing Economies	26,0	27,6	32,4	39,2	33,4	29,2	29,1	36,3	43,3	47,1	44,9
Transition Economies	0,9	1,8	3,4	4,1	3,1	3,7	4,6	6,8	6,0	5,6	6,0
OECD	80,9	32,7	31,8	29,9	23,6	25,0	29,7	38,7	70,2	66,9	40,8
EU	41,5	49,7	46,7	30,3	50,9	40,0	43,2	30,3	29,8	24,3	27,6
	Outward flows (in %)										
World	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**
Developed Economies	89,5	90,1	89,9	85,2	83,5	81,4	83,2	80,3	73,0	68,2	73,0
Developing Economies	10,3	9,0	8,2	13,3	14,9	16,9	14,4	16,7	22,8	27,6	22,6
Transition Economies	0,2	0,9	1,9	1,5	1,6	1,7	2,3	3,1	4,2	4,2	4,3
OECD	89,6	429,7	429,3	425,1	411,2	404,0	417,5	400,8	392,4	382,9	394,8
EU	55,9	49,2	50,8	40,1	68,0	48,9	54,8	48,6	33,5	33,3	33,2

** annual average;*

Source: our computations on UNCTADstat.

Tab. 1.3 – *Inward and outward FDI stocks in considered regions in 2002-2011.*

Rregion/Country	1981-2001*	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Inward stocks (in million US$ at current prices and current exchange rates)										
World	2962593,3	7501217,3	9387520,6	11100663,7	11563007,5	14300408,9	17901073,1	15451284,8	18041009,2	19906661,7	20438198,7
Developed economies	2190298,0	5654946,7	7253576,8	8577849,8	8577412,4	10550382,4	12738241,9	10812730,3	12296706,1	12890908,5	13055902,8
Developing economies	757971,8	1730851,8	1979882,6	2325396,9	2712819,7	3355031,0	4487488,8	4214287,2	5120181,9	6256066,3	6625031,7
Transition economies	14323,5	115418,8	154061,3	197417,1	272775,4	394995,5	675342,3	424267,3	624121,3	759686,9	757264,2
Total OECD	2292618,6	6065296,8	7688400,5	9070541,7	9178225,7	11204992,5	13501177,8	11474842,2	13214516,3	14054770,1	14261941,2
European Union	958524,9	2958991,7	3923359,7	4800899,6	4731893,0	5983519,7	7503020,3	6653978,9	7322963,0	7289628,8	7275621,6
	Outward stocks (in million US$ at current prices and current exchange rates)										
World	3055446,4	7785795,5	9916512,4	11694926,6	12464846,8	15697204,3	19272590,8	16342808,9	19325745,6	20864846,1	21168488,7
Developed economies	2756696,0	6811666,8	8823480,2	10413691,9	10951816,6	13636336,3	16367069,9	13648378,2	16152431,7	17144627,8	17055963,5
Developing economies	293269,2	909003,0	998158,7	1169747,3	1360935,3	1837998,5	2517784,7	2463068,9	2834914,5	3313807,7	3705410,3
Transition economies	5481,3	65125,7	94873,4	111487,3	152094,9	222869,6	387736,2	231361,9	338399,5	406410,6	407114,8
Ttoal OECD	2748624,2	6913179,4	8918357,6	10528618,9	11095453,3	13807628,0	16599613,7	13952748,7	16643731,0	17699315,3	17726906,8
European Union	1198778,6	3716478,0	4826124,1	5551909,1	5742144,2	7216880,2	8738232,0	8115395,9	9127113,8	9243523,3	9198831,8

** annual average;*

Source: UNCTADstat.

Tab. 1.4 – *Inward and outward FDI stocks in considered regions in 2002-2011 (% of the total).*

Rregion/Country	1981-2001*	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Inward stocks (in million US$ at current prices and current exchange rates)										
World	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Developed economies	73,9	75,4	77,3	77,3	74,2	73,8	71,2	70,0	68,2	64,8	63,9
Developing economies	25,6	23,1	21,1	20,9	23,5	23,5	25,1	27,3	28,4	31,4	32,4
Transition economies	0,5	1,5	1,6	1,8	2,4	2,8	3,8	2,7	3,5	3,8	3,7
Total OECD	77,4	80,9	81,9	81,7	79,4	78,4	75,4	74,3	73,2	70,6	69,8
European Union	32,4	39,4	41,8	43,2	40,9	41,8	41,9	43,1	40,6	36,6	35,6
	Outward stocks (in million US$ at current prices and current exchange rates)										
World	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Developed economies	73,9	75,4	77,3	77,3	74,2	73,8	71,2	70,0	68,2	64,8	63,9
Developing economies	25,6	23,1	21,1	20,9	23,5	23,5	25,1	27,3	28,4	31,4	32,4
Transition economies	0,5	1,5	1,6	1,8	2,4	2,8	3,8	2,7	3,5	3,8	3,7
Ttoal OECD	77,4	80,9	81,9	81,7	79,4	78,4	75,4	74,3	73,2	70,6	69,8
European Union	32,4	39,4	41,8	43,2	40,9	41,8	41,9	43,1	40,6	36,6	35,6

** annual average;*

Source: our computations on UNCTADstat.

The FDI flow reaching developed countries also grew consistently during the entire considered time. It rose from 443,431 million US$ in 2002 to 1,310,425 in 2007. After a significant fall in the next two years, which brought the investment level to 606,212 million US$ in 2009, the FDI flow began to go up again to reach 618,586 million in 2010 and 747,860 million in 2011. This performance shows an increase of the investment inflow of 21% between 2010 and 2011, although it is still a quarter below the level of the pre-crisis three-year average.

In addition, the investment flow to developing and transition economies increased between 2002 and 2008. On the one hand, developing countries experienced an increase from 173,283 million US$ in 2002 to about 650,017 million in 2008, which was followed by a decrease to 519,225 million in 2009 and a new increase to about 616,661 million and 684,399 in 2010 and 2011 respectively. On the other hand, the investment flow in transition economies jumped from about 11,260 million US$ in 2002 to about 121,041 million in 2008. A decrease in 2009, which brought the level to 72,386 million, was followed by two new increases to about 73,754.5 in 2010 and about 92,163 million US$ in 2011. The contribution of the FDI inflow in both developing and transition economies to the global flow of inward FDI constantly increased over the whole considered period. It moved from about 29% in 2002 to about 53% in 2010 and 51% in 2011 (when their contribution was 45% and 6% respectively). This growth was also recorded during the worst years of the global economic turmoil and shows the economic dynamism and the strong role they can play in the future. According to details given in the UNCTAD (2012) report, the increase of FDI to developing economies was generated by an increase of 10% in Asia and 16% in Latin America and the Caribbean. It is the case to highlight that table 1.1 is developed with the aim of highlighting the role of the OECD[13] and European Union areas in the distributional dynamic of the world FDI inflow. As can be

[13] For the reasons which will be explained later in footnote 40, the OECD countries we refer to are: 1) Australia; 2) Austria; 3) Belgium; 4) Canada; 5) Czech Republic; 6) Denmark; 7) Finland; 8) France; 9) Germany; 10) Greece; 11) Hungary; 12) Iceland; 13) Ireland; 14) Italy; 15) Japan; 16) Korea Republic; 17) Luxembourg; 18) Mexico; 19) Netherlands; 20) New Zealand; 21) Norway; 22) Poland; 23) Portugal; 24) Slovak Republic; 25) Spain; 26) Sweden; 27) Switzerland; 28) Turkey; 29) United Kingdom; 30) United States of America.

observed, the FDI inflow reaching the OECD countries was about 205,047 million US$ in 2002 and – apart from a reduction to about 186,700 million in 2003 – increased during all the considered period (even in the years of the economic crisis) arriving to a level of 875,218 million in 2010. A new decrease was recorded in 2011 when the amount fell to about 621,442 million US$. In terms of contribution to the global FDI inflow dynamic, it can be observed how in 2002 the OECD area attracted about 32% of the total world flow. This percentage almost constantly declined over the next years to reach a level of about 30% in 2007. In the years of the global economic crisis, it rose to 38.7% in 2008 and 70.2% in 2009 to fall down to about 67% in 2010 and 41% in 2011.

The European Union area is one of the major attractors of the FDI inflow worldwide. In 2002 it attracted 312,003 million US$ (that is 50% of the FDI inflow moving worldwide). After a decline in the next two years, the amount rose to about 542,242 million in 2008 (about 30% of the FDI global inflow). After a new decline in 2009 and 2010, when the amount reached 356,631 (about 30% of the global inflow) and 318,277 (about 24%) million US$ respectively, the FDI inflow rose again to 420,715 million, although at a lower level than those recorded in the four pre-crisis years.

A very short analysis of the outward FDI makes us observe how its flow from developed countries continuously increased from 2002 to 2007 moving from 476,341 to about 1,830 billion US$. After a decrease recorded during the crisis period, it returned to a consistent increase of about 25% between 2010 and 2011, reaching about 1.237 billion US$ in the last considered year. This increase was the result of the operations deriving from the three major developed-economy investor blocs (the European Union, North America and Japan), although the driving factors differed for each. FDI from the United States was driven by a record level of reinvested earnings (82% of total FDI outflows), partially driven by TNCs building on their foreign cash holdings. The rise of FDI outflows from the European Union was determined by cross-border M&As. Japanese TNCs doubled their FDI outflow through M&A purchases in North America and Europe (+132%) as a result of an appreciation of its national currency (UNCTAD, 2012).

The outward FDI flow generated by developing economies shows a generally decreasing trend between 2002 and 2010. With more specific regard to the last two years of the considered period, it shows a decline of 4% moving from 400,144 to about 383,754 per cent to $384 billion between 2010 and 2011, although its contribution to the global FDI outflow remained at 23%. In the last considered year, the flows from Latin America and the Caribbean fell by 17%. Among the main reasons for this decrease is the repatriation of capital to the considered country areas (counted as negative outflows), which was partially motivated by financial considerations (i.e. exchange rates, interest rate differentials). Once again, with reference to the last year of our considered period, the FDI outward flow from East and South-East Asia was largely stagnant. A 9% decline was recorded with respect to the outflow of FDI from East Asia, while outward FDI from West Asia increased significantly to $25 billion (UNCTAD, 2012).

To comment on the sectoral distribution of the FDI flows, an analysis of the statistics between 2008 and 2011 allows us to observe how it rose in all three sectors of primary, manufacturing and services. According to FDI projects data (comprising cross-border M&As and greenfield investments) dispatched by UNCTAD and reported in tab. 1.5 here below, the FDI flow destined to projects in the primary sector rebounded in 2011 to a level of 200 billion US$ after a significant fall in 2009 and 2010. An analogous situation can be the investment dynamic in the service sector, which reversed the negative trend of the previous two years and reached 570 billion US$ in 2011. As can be appreciated by looking at the part of the table where the percentages are shown, the share of these two sectors rose slightly at the expense of manufacturing, which reached 660 billion US$ in 2011 after having experienced a sharp decline in the two previous years. From what is said in the last world investment report by UNCTAD (2012), it is possible to learn how the top five industries contributing to the rise in FDI projects were extractive industries (mining, quarrying and petroleum), chemicals, utilities (electricity, gas and water), transportation and communications, and other services (largely driven by oil and gas field services).

Tab. 1.5 – *Sectoral distribution of projects related to the global FDI flow (2008-2011).*

Year	Value (in bln. US$)			%		
	Primary	Manufacturing	Service	Primary	Manufacturing	Service
2005-07*	130	670	820	8	41	51
2008	230	980	1130	10	42	48
2009	170	510	630	13	39	49
2010	140	620	490	11	50	39
2011	200	660	570	14	46	40

** annual average;*
Source: UNCTAD, World Investment Report 2012.

With regard to the prospects, it must be highlighted that because of the economic uncertainty and the probability of lower growth rates in major emerging markets there is an objective risk of seeing the generally favourable trend of the last couple of years undercut. UNCTAD foresaw that the FDI growth rate would slow in 2012. Leading indicators are suggestive of this trend, with the value of both cross-border M&As and greenfield investments retreating during the considered year. As a result, it was believed highly likely that in 2012 the FDI inflow would grow very moderately in all the three identified macro-regions, namely developed, developing and transition economies. Among the countries belonging to the developing regions, Africa is referred as a particular case since its FDI inflow is expected to increase. A very moderate FDI growth is also expected to happen in Asia (including East and South-East Asia, South Asia and West Asia) and Latin America. Similarly to Africa, however, the FDI flows to transition economies was also expected to grow further during 2012 and in the next couple of years (UNCTAD, 2012).

To conclude this section, we move very briefly onto referring to the prospects expected for the next few years. In the short-medium run UNCTAD predictions show that, although investor uncertainty is still high, the global FDI flow will continue to grow at a modest but stable pace reaching 1.8 trillion US$ in 2013 and 1.9 trillion US$ in 2014, barring any macroeconomic shock (UNCTAD, 2012). This should be the result of the feeling recorded by the World Investment Prospects Survey (WIPS), which is run yearly by UNCTAD and pools the Chief Executive Officers (CEOs) of TNC on their investment plans. This yearly survey reveals that, although the number of pessimistic CEOs is 10% higher than the number of those optimistic, the largest group of respondents (about 50%) are neutral or undecided. However, a more optimistic view is expressed by respondents in the longer run after the end of 2012. In fact, more than half of them foresees an increase – compared with the situation in 2011 – of their planned FDI expenditure between 2012 and 2014. Although the forecasted increase of the FDI flow will be driven by developed economies, indications also suggest that in the short-medium term developing and transition countries will continue to keep up with global FDI growth. Responses given by CEOs to the WIPS of 2012 rated six developing and transition economies among their 10 future investment destinations by the end of 2014, with Indonesia among the five top destinations for the first time (UNCTAD, 2012). Table 1.6 below reports the projection of FDI growth in the short-medium run, resulting from the econometric analysis performed for the WIR 2012.

Tab. 1.6 – *Summary of econometric results of medium-term baseline scenarios of FDI flows by region (in billion US$).*

Host region	Averages		FDI flows			Projections		
	'05-'07	'09-'11	2009	2010	2011	2012	2013	2014
Global FDI flows	**1473**	**1344**	**1198**	**1309**	**1524**	**1495-1695**	**1963-1925**	**1700-2110**
Developed countries	**972**	**658**	**606**	**619**	**748**	**735-825**	**810-940**	**840-1020**
European Union	646	365	357	318	421	410-450	430-510	440-550
North America	253	218	165	221	268	255-285	280-310	290-340
Developing countries	**443**	**607**	**519**	**617**	**684**	**670-760**	**720-855**	**755-930**
Africa	40	46	53	43	43	55-65	70-85	75-100
Latin America and the Caribbean	116	185	149	187	217	195-225	215-265	200-250
Asia	286	374	315	384	423	420-470	440-520	460-570
Transition economies	**59**	**79**	**72**	**74**	**92**	**90-110**	**100-130**	**110-150**

Source: UNCTAD, 2012.

1.5. Remarks and conclusions.

In this chapter we have discussed some basic aspects of the FDI phenomenon and introduced some issues to understand to what extent links between FDI and the natural environment can be identified. More specifically, after having presented a couple of sections where FDI is defined and identified in its qualitative and quantitative features and where its effects are explained, the chapter proposes a section where a description of the main trends and prospects of the FDI phenomenon is reported. The observation of the data dispatched by various international organizations and, especially, the UNCTAD shows that the global flow of FDI will grow moderately in the short-medium term, although economic uncertainty levels deriving from the shrink which has hit the world economy in recent years still exist. On the basis of what has been said, the FDI growth expected in the next few years represents a potential condition which could harm the natural environment and should encourage us to make more effort in understanding whether and how FDI affects it. The production of as much empirical evidence as possible can contribute to a better understanding of the dynamics associated to the FDI-environment relationship. Only in this way will it be possible to help the policy-making activity of governments to pursue a more conscious production of regulations for the implementation of more sustainable ways of managing investment activities. With regard to this, it could be useful to conclude this chapter by recalling a concept redundantly expressed in the international literature and especially in those works developed by international organizations such as the OECD. It highlights that whether FDI is really functional for development and, in particular, for sustainable development, depends especially on the way it is managed by the receiving countries' governments, which in turn depends on their vision of economic development and environmental conservation management. In other words, it all depends on their policy and regulatory frameworks.

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Chapter II

A literature review on the relationship between FDI and the natural environment

2.1. Introduction.

The relationship between FDI and the environment can be considered as a subset of the FDI literature and, especially in the last decade or so, it has been abundantly treated by academicians, politicians and experts. This has generated a massive production of writing, whose analysis is not straightforward. From a methodological point of view, two basic ways of empirically analysing the issue can be observed in the literature. The first looks at the statistics of FDI flows, environmental data and information on the environmental regulatory systems of various considered countries or areas in the attempt to identify the existence of some linkages between the two aspects. The second considers the behavioural aspect of firms to understand how they make their investment location decision and if environmental factors play a role in this process. Relevant information on these issues can be found in various UNCTAD reports and especially in two of them (UNCTAD, 1999; 1993). The first, which is still now generally recognized as the most comprehensive study of the environmental performance of MNCs, basically refers that larger companies are more likely to have better management performance. The second contains a useful update of the previous and a valuable discussion on the environmental effects of FDI in emerging economies. Additional information can be found in some other useful works produced by the OECD, where the research developed is categorized into four macro themes, which we will refer to with the aim of presenting a methodologically clear discussion of the specific literature. However, for the convenience of our discussion, we group the issues analysed on the FDI-environment relationship into three thematic areas: 1) the environmental effects of FDI flows; 2) the competition for FDI and its effects on environmental standards; 3) the cross-border environmental performance (OECD, 2002[a]; 2002[b]; 1997)[14].

2.2. The environmental effects of FDI: scale, composition and technique effects.

The first vein of discussion, related to the environmental effects of FDI, is claimed to be one of the research areas where the literature lacks a better and more appropriate scientific understanding (OECD, 2002[b]). Even at the time of writing, this research field still appears largely unexplored since – as has been already mentioned above – a great deal of the scientific work developed insofar has focused more on the environmental features eventually influencing the location of the investment decision of firms and the countries' environmental regulatory competition for FDI rather than on this aspect. Although some works have been done to cover the gap in this thematic area, a strong call for further research still exists. This body of discussion comments on how FDI can generate benefits and costs or, which is likely the same, opportunities and risks. This is particularly true for host or receiving countries of FDI and their communities. For example, FDI may boost economic growth, generate structural efficiency together with other positive effects, but it can also generate environmental degradation. Indeed, FDI can spread industrial activity, stimulate the production and consumption of industrial polluting goods, all this resulting in an increase of the sources and forms of pollution. However, it is also often argued – and this has been proved to be more than a simple hypothesis – that foreign investors bring new technologies to receiving countries. This would enable receiving countries to implement environmental protection projects and actions. In this perspective, the

[14] A fourth area can also be considered, which is represented by the regulatory impact of investment rules. Although this is referred to be the most recent area of work, so far it has basically focused on understanding whether or not investment and environmental protection are pursuable as a common achievement. Furthermore, most of the work carried out in this field of discussion has taken into consideration the analysis of investment models and agreement regulations such as those in the North American Free Trade Agreement (NAFTA), the OECD Multilateral Agreement on Investment (MAI), and Bilateral Investment Agreements (BITs) (OECD, 2002[b]). Since the rationale of the studies conducted in this field seems more focused on the analysis of the juridical content of agreements (e.g. Ignacio, 2003) and takes a different direction from the scope of our work, we purposely fail to report a more extensive description of it in the conviction that a sufficient note can remain in these few lines.

economic expansion driven by FDI may also generate a generalized improvement in the environmental sphere. For this reason, some authors point out that FDI should be considered neither a boon nor a bane. It is both, since the wide differences of locations, sectors and investors involved in FDI allow us to find evidence to support both views (i.e. Gentry, 1999). Indeed, depending on each specific circumstance, examples of the existence of environmental positive or negative marginal effects of FDI can be found in some countries and not in others. With regard to this, the literature claims a lack of studies able to identify the "net effect" of FDI on the environment[15]. However, this might be seen as a complex – or even impossible – job to do, because of the existence of two constraints. The first refers to the extreme difficulty in discriminating the effects of the activity run by domestic industries from those of foreign firms or their affiliates. Furthermore, FDI does not occur as an isolated phenomenon in affecting the environmental sphere, but it also interacts very strictly with other linked factors. For this reason most of the studies on the environmental effects of FDI are carried out by decomposing them into scale, composition (or structural) and technique (which is also associated to a technological aspect) effects. Very briefly, while scale effects refer to the results of the expansion of the economic output, composition and technique effects respectively refer to the change of the industrial structure of an economy (due to a reallocation or reorganization of the production and consumption structure) and to changes of the production methods associated to the development and diffusion of technology (OECD, 2002[b]).

More specifically, scale effects would refer to the impacts that the increment of an economic activity - arising from the entry of new foreign investment to be

[15] Although this approach of analysis is often said to be desirable, the difficulties implicitly existing in its performance would impede the achievement of meaningful results. As reported by UNCTAD, there are plenty of studies which have come to the same conclusion in demonstrating that specific industrial activities (such as those related to production in the sectors of chemical and allied, pulp and paper, mining for mineral and iron, cement, glass and ceramics) may result highly pollutant. However, because of data insufficiency, research has failed to prove the existence of precise relations between FDI flows and the potential pollution intensity of these considered industry sectors. Hence, the report highlights that the "net effects" of FDI on the environment depend on a combination of macro and micro aspects. The first can be related to the FDI profile such as, for example, the type of industry sector in which it takes place, and the extent to which it involves pollution-intensive activities. The micro aspects could refer to specific decisions with regard to the management of their production activities and the adoption and diffusion of environmentally sound technologies (UNCTAD, 1999).

consistent with the context of our discussion – generates on some considered environmental features of host countries. These types of effects are normally expected to be detrimental and negative to the environment and can be easily understood if the case of resource-intensive industry sector is referred to. Particularly in this sector, the increase of production requires the use of – that is the extraction of – more resources and the generation of more waste (O'Connor, 2000)[16]. The existence of a debate can be further observed with regard to the determination of the size of the scale effects (Nordström & Vaughan, 1999), which is followed by some clarifying work stating that this basically depends on the environmental feature one investigates (OECD, 2001).

However, a different view is expressed in other works where the existence of an "inverted-U" relationship – also known as Environmental Kuznets' Curve (EKC) – between environmental quality and economic growth is discussed. They refer that economic expansion can alleviate, or even counterbalance, the detrimental result of the scale effects on the environment because of the technological innovation and the increase of environmental quality demand implicitly living in it. Evidence of this has been produced by various relevant works in the past decade[17]. Hence, according to this view, countries with an economic growth induced by FDI inflows may experience a deterioration of their environmental quality – due to the increase of their pollution caused by the boost of industrial activities – at the beginning of their process and up to a certain stage. Afterwards, pollution levels should start to decline because of the increase of a demand for environmental quality taking place in association with the increase of

[16] However, as proof of the difficulty of arguing about the direct relationship between FDI and the environment, a consideration that technological innovation may play an offsetting role by bringing more resource-use efficiency is also made.

[17] Some of the most relevant contributions on this research theme were produced with the support of the World Bank (WB). For example, some works found a positive relationship between environmental regulation and the growth in the population per-capita income (Dasgupta et Al., 2001). Other works verified how many indicators of environmental quality deteriorate at an initial stage of economic growth, but they improve when economic welfare overtakes certain thresholds (Seldon & Song, 1994; Shafik, 1994; Grossman & Krueger, 1993[a]; 1993[b]; 1995; Shafik & Bandyopadhyay, 1992). A more recent work, while focusing on an analysis of air and water pollution with regard to a set of 120 countries observed over a time span between 1960 and 2001, finds the existence of the EKC for water (Gassebner et Al., 2011). However, other works expressing an opposite view and showing completely different results concerning the inexistence of the EKC are also extensively reported in the literature (e.g. Stern, 2004[a]; 2004[b]; Perman & Stern, 2003; Yandle et Al., 2002).

the economic welfare of the population[18]. Having reported all this, however, it must be stressed that for the reasons already mentioned above, a wider debate on the FDI-environment relationship cannot be identified. The issue suffers from the lack of data and analysis and is almost basically limited to the concepts and reflections referred. The literature analysis also highlights that, due to the difficulty in conducting studies for the straight identification of net effects between FDI and the environment, researchers changed their analytical approach at a certain point and came to focus more on case studies – many of which are from Asian countries – with the aim of understanding the environmental impact and the management strategies of foreign firms. Even these analyses do not definitively resolve the debate, since evidence of positive as well as negative environmental effects is found (Guaoming, 1999; Jha, 1999). More recent evidence can be tracked in other works which investigate the metal mining sector of some countries of the Sub-Saharan African region (Ghana, Tanzania and Zambia), where MNCs are found to cause both negative and positive effects on the environment. While the negative effects can be mainly referred to as deforestation, air, water and dust pollution, the beneficial aspects are represented by the adoption of better management practices and the introduction of environmentally-friendly technologies, these giving rise to positive technological effects in the sense that will be disclosed later in the paragraph (Kulindwa, 2003 cited in UNCTAD, 2007; George, 2003; Boocock, 2002; Warhurst, 1998; Aubynn, 1997)[19].

Broadly speaking composition (or structural) effects are associated with the adjustment within and between economies when a shift occurs in the pattern of

[18] The achievement of a detailed survey of the EKC literature is certainly not the scope of our discussion. However, it seems the case to highlight that a series of limitations arise to cool the optimistic feeling which may be generated by approaching the view expressed by the EKC issue. As reported by authors who have profoundly characterized this scientific debate, in many countries the “turning point” of the inverted-U curve could be found at quite a high level of their population’s per-capita income, this opening the way to the fear of irreversibility of environmental degradation meanwhile generated (Panayotou, 2000; 1997; Opschoor, 1995). Furthermore, the EKC shows its validity only for some pollutants, for some countries and not all the times (Munasinghe, 1999; Barbier, 1997). Finally, some empirical evidence of the linkage between economic growth induced by trade and environmental deterioration exists, but this does not mean the same relationship can be validated for FDI-induced growth (Dessus & Bussolo, 1996).

[19] More specifically, some of the mentioned studies also refer that, in the attempt to offset such degrading situations, MNCs have introduced more environment-friendly technologies and higher standards of environmental protection in comparison to the local firms working in the same sector.

economic activity, including a shift from one production sector to another or from one product to another, changes in the price of input factors and final products, changes in industry ownership, changes in efficiency.

A more focused view on the environmental consideration would see a structural effect when a shift in the pattern of resource use occurs (OECD, 2001). On the assumption that trade and investment liberalization encourage allocative efficiency among countries, these effects are expected to have a positive impact on the environment. For a better understanding of this aspect, it is useful to highlight that the efficiency concept implies that goods are produced with lower labour and capital inputs, which as a result also means a decreasing impact on the natural resources system. According to the last available UNCTAD report, FDI flows have experienced structural shifts which can be observed at geographical and sectorial levels[20].

With particular regard to the sectorial shift, the arising question highlighted in the literature under analysis tries to understand to what extent the FDI shift towards the service sector can result beneficial to the environment. Some approaches in the literature support this hypothesis. For example, they argue that newly industrialized countries can move from the primary to the service sector passing through a low polluting light-manufacturing production experience. This should allow them to actually jump phases of heavy industrialization, such as those experienced by the traditional industrialized countries during certain phases of their economic history, thus gaining significant environmental advantages

[20] From a geographical point of view, in the past decade the pattern of the FDI dynamic has changed enormously. New world areas have come to the spotlight as host and receiving countries. Shifts in the patterns of bilateral FDI relationships can also now be observed among developed countries, and between developed and emerging economies. The analysis of recent trends shows a significant increase of FDI flows from developing and transition economies and in the South-South relationships (UNCTAD, 2007). From a sectorial point of view, it can be appreciated how over the past 25 years FDI has grown notably in absolute terms in the three main economic sectors (primary, manufacturing and services). However, the observation in terms of stock shows the primary (particularly referred to the natural resource sub-sector) and manufacturing quotas have considerably decreased. Meanwhile, a significant shift in favour of the service sector can be appreciated. In terms of FDI stock, in fact, while the primary sector in 2005 represents one tenth of the total, that is a slight decrease with respect to the figure in 1990, the manufacturing sector accounts for 30% of the total in 2005 against 41% in 1990. The FDI stock in the service sector performs a significant increase arriving to represent 61% of the total in 2005 against 49% in 1990 (UNCTAD, 2007).

(OECD, 2001; Gentry, 1998)[21]. Another analysis states that the service sector is the one where the implementation of better environmental practices is more likely to happen. It supports this hypothesis by referring to the hotel sector as an example in which FDI induced practices for a more efficient use of water, energy and waste are more widely put into action, thus generating positive environmental effect (UNCTAD, 1999). As a counter fact, a case study by WWF (2001), while recognising the beneficial effect of FDI in tourism activities, also stresses its possible negative effect on the environment. The benefits can be particularly seen in terms of income generation, which also allows the creation of infrastructure and facilities for environmental protection. The negative aspects may be related to the ownership structure of tourism service facilities. In fact, when the tourism sector is driven by FDI – and this is the case in many developing economies – this would imply that the economic benefit will almost always flow out of the FDI host country, where it was generated, while environmental costs generated by the running of the activity and tourist use of the territory will remain upon the shoulders of the local communities. Another question is also posed by the literature and refers to the understanding of whether or not the world economic structural shift in favour of the service sector will push manufacturing industries to move from developing to rapidly industrializing countries, thus giving rise to some negative environmental implications (O'Connor, 2000). Although research is claimed on this aspect, available empirical evidence shows that FDI flows to the service sector of developing countries is an increasing phenomenon and, on the basis of the consideration of some data, it seems supported not only by service-based MNCs but also by the establishment of others operating in the other two sectors (UNCTAD, 1999; 2007).

The aspect of technique (or technology) effects refer to the development, transfer and diffusion of technology as a phenomenon associated to the movement of international investment flows. This can happen through the transfer of physical goods (i.e. capital goods) and the transfer of tacit knowledge (UNCTAD,

[21] With regard to this, however, a reflection should be made with regard to the different nature of the many activities characterizing the service sector (e.g. the difference between financial and air transport services) and to the different environmental impacts they can generate. This considered, further research is claimed for a better understanding of the wide variety of environmental impacts which can arise from the service sector activities (OECD, 2002[b])

1999). In a free trade and investment context, technology effects would normally be expected to exert a positive (or at least neutral) impact on the environment (OECD, 2001). However, other views show how this cannot always be considered the rule of thumb. For a better explanation of these two different ways of thinking, it is worth highlighting how technology effects can be seen under the consideration of a double hypothesis. In some situations, foreign investments can certainly generate positive spillover in the environmental sphere of the investment host country, as a result of the use of environmentally-friendly technologies in producing goods and exploiting resources. In this direction goes, for example, the evidence produced in some works already mentioned. In analysing the technological side of the Chinese FDI inflow, the study refers that foreign investors have introduced better technologies and more appropriate environmental structures and practices which were inexistent in the country before (Guaoming et Al., 1999). Other works suggest that the presence of MNCs working with new technologies in host countries can also represent a push or an incentive for national and local firms to implement similar production methodologies. As has been observed, in a comparison with more advanced and better organized MNCs, domestic firms may feel an incentive to imitate their production schemes. In this way a so-called "reverse engineering" process starts, although it can be strongly conditioned by the more or less rigidity of the property rights system (Panayotou, 2000; Blömstrom & Kokko, 1996; Coe & Helpman, 1995)[22]. Similar empirical evidence is also produced by a relatively recent work which analyses the Vietnamese investment context in the manufacturing sector while exploring – among other aspects irrelevant to the purpose of our discussion – whether or not FDI generates vertical or horizontal technology spillover on domestic firms through the use of a panel data technique. The study concludes by confirming that FDI is found to be a relevant tool to improve production efficiency and expand the

[22] Furthermore, the study by Blömstrom and Kokko (1996) highlights that the presence of multinational firms in a country seems to generate further technological spillover among the supplier industries, which can be beneficial to the environment. In fact, by requesting factor inputs (e.g. raw material, component parts, etc.) with specific quality standards and furnishing supplier firms with appropriate technical aid to achieve the required standards, multinationals can encourage these firms to improve their technological performance. For other aspects, the same study also reports the observation of other beneficial spillovers, which can arise when people and experts previously employed in international firms – especially when they are the subject of significant training programmes – are successively engaged by national and local firms.

small and inexperienced domestic enterprise of the considered sector (Nguyen et Al., 2008). Conversely, in other situations technology may have a negative impact on the environment by playing a detrimental effect. This can happen, for example, when the object of the technological transfer is either archaic and obsolete equipment or machinery or technology banned in the FDI source country due to the previous knowledge of its negative environmental effects (OECD, 1997). In a small number of cases, evidence of this "technology dumping" is reported with regard to some cases of companies which were dismantling obsolete production plants in industrialized countries to move them to emerging economies (Esty & Gentry, 1997). Similar evidence is reported with regard to the Chinese leather, footwear and plastic sectors, where in the past Asian investors were seen to implement very poor environmental performance, thus negatively affecting the environment and the health of the local communities (Guoming et Al., 1999). Yet another example comes from Malaysia, where observations were made of the very low environmental practices implemented by some MNCs in the chemical and copper mining sectors and in the disposal of radioactive residuals of production processes (Rasiah, 1999). At other times, it is found that technology implemented in foreign investors' firms does not play any relevant role in generating beneficial spillover to the domestic firms of host countries. An investigation related to the Estonian transitional economy on the existence of spillover from technology transfer to domestic firms and the relationship between this spillover and the capacity of domestic firms to absorb them shows how spillover from technology transfer depends on a number of aspects, such as the size of the receiving firm, its trade orientation and its ownership structure. The study finds that small, non-exporting and foreign firms gain a higher beneficial effect from spillover than domestic firms are able to do. In fact, in contrast to the expectations, domestic firms do not enhance their ability to attract the beneficial aspects of technology spillover by failing to catch up with foreign firms in most industries, thus failing to bring in a higher level of efficiency in their production schemes (Sinani & Meyer, 2004).

Moving away from those works specifically related to the analysis of each single effect we have just mentioned, the most recent literature shows how researchers have come to follow new approaches to investigate the FDI-environment relationship. This vein of research is richer in works focusing on the trade-environment relationship rather than the FDI-environment one[23]. Apart from this, however, the new approaches consist in developing analysis while considering the empirical evidence as associated to all these aspects (scale, structural or composition and technique or technology effects) together. For example, while focusing on the trade issue, some authors consider scale, technique and trade-induced composition effects while using Sulphur Dioxide (SO_2) data for 43 countries over the period between 1971 and 1996. Their empirical result shows consistently higher elasticity of technique effect over scale effects. In their study, trade-induced composition shows a generation of positive consequences for the environment. They conclude by saying that free trade is good for the environment (Antweiler et Al., 2001). This result is partially supported by a complementary study by Cole and Elliott (2003), who assess a combined scale and technique effect for SO_2, Nitrogen Oxides (NOx), Carbon Dioxide (CO_2), and Biological Oxygen Demand (BOD). They find technique effects are dominating scale effects for SO_2 and BOD with scale effects dominant for NOx and CO_2.

With more specific regard to the FDI-environment relationship, for example, a work aimed at understanding whether or not FDI is harmful to the Chinese environment finds a negative relation between the FDI inflow and the air quality measured in terms of SO_2 emissions, thus stating that FDI generates a beneficial effect to the environment of the host country. Benefits happen thanks to a process of technological innovation (the technology effect), implicitly associated to the foreign investment dynamic, which brings higher levels of production efficiency and pollutant abatement as a result (Liang, 2006). A different view is referred by the evidence produced by another author and his panel data model built for the period between 1994 and 2001 with regard to 29 Chinese provinces affected by industrial SO_2 emissions. He observes a positive relation between the

[23] We also make reference to the trade issue, since we are aware of the fact that FDI and trade can be intended as the two faces of the same coin. It is generally recognized that the perception, which has been empirically proven in most cases, that trade and FDI are interlinked in various modes and they are two ways – sometimes alternatives, but increasingly complementary – of servicing foreign markets (ie. Chaisrisawatsuk & Chaisrisawatsuk, 2007; Hejazi & Safarian, 2001; Baldwin, 1994).

inward FDI stock and the emission levels of SO_2: a 1% increase in the FDI stock generates a 0.098% increase in SO_2 emission levels. He relates this overall very small negative impact of FDI on the environment to the fact that the country produces a relatively higher pollution efficiency level as a result of the technology effect and to a composition effect, which is heavily influenced by the inflow of foreign capital in searching for lower compliance costs of pollution regulation (He, 2006). Another similar view is expressed in a more recent work, where the FDI-environment relationship is investigated over the period between 1985 and 2006 for 110 developed and developing economies. Through the use of the econometric technique of panel data, the study finds a significant and positive linear relationship between the two considered aspects of the flow of foreign direct investment and energy emissions considered in terms of CO_2. The authors conclude by saying that the increase of FDI generates increases in the levels of environmental degradation (Shahbaz et Al., 2011). Through the use of a panel data set of 29 Chinese provinces for the period between 1992 and 2004, another study investigates the effect of FDI on the emission levels of five different pollutants and assess the technique, scale and composition effects. The analysis result shows that, although FDI contributes to the reduction of pollution emissions in the whole of China, the FDI environmental impact varies significantly among different regions and pollutants (Bao et Al., 2011).

As can be observed, these works – as the majority of the research carried out in this thematic context – focus their attention on the FDI-environment relationship while working on aggregated data and disregarding the specification of the activity sectors, which in our view should be taken into consideration for a more thorough investigation. In this direction another recent work investigates French data of the FDI outflow, disaggregated at sectoral level, which reached a mix of developed, emerging and developing countries between 1999 and 2003. Through the use of a simultaneous equations model and among other analysis targets, it also assesses the FDI impact on the environment (this considered in terms of CO_2 and BOD emissions) of host countries. The result shows a positive relationship between the FDI outflowing to the manufacturing sector of host countries and CO_2, this showing the existence of a carbon leakage dynamic. A different result is achieved, instead, with regard to the relationship between FDI outflowing to the manufacturing sector of host countries and BOD water emissions which shows an inverse relationship (Ben Kheder, 2010).

The examination of this part of the literature on the environmental effects of FDI does not give us a clear understanding of whether or not FDI affects the environment positively, negatively or neutrally. Results are specifically related to the context of the analysis where they are achieved. As observed, in fact, a wide part of the scientific debate and the production of analyses as a result concentrate on only one dimension of the three different categories (either scale, or structural composition, or technology effects) of the FDI-environment relationship. Apart from some more recent works, studies still seem to fail to consider these three aspects all together. For this reason, a call for further research in this area is generally made. Furthermore, according to some ideas, an interesting point which still does not seem to be properly addressed is the understanding of whether the structural shift most countries are experiencing by moving from the manufacture to the service sectors is environmentally valuable (OECD, 2002[b]).

2.3. The competition for FDI and its effect on environmental standards.

The second theme on the competition for FDI and its effect on environmental standards basically refers to the body of literature in which much of the debate on the FDI-environmental relationship has been developed so far[24]. It considers the development of a reflection process, whose mainstreams could be seen as two sides of the same coin: the impact of environmental standards on the location of firms' investment decisions and the environmental effects of international countries' competition for FDI.

The first basically tries to understand if the existence of countries with different environmental regulations and standards can be a reason for firms relocating their activity[25]. The latter analyses the implication of the FDI-

[24] This is particularly true with regard to the issues of the location of firms' investment decisions as related to the "pollution haven" and "pollution halos" hypothesis, which will be explained later in this section.
[25] For the purpose of completion, it is worth referring that the aspect related to the environmental regulation is often seen to play a very minimal role in the decision process of investment location.

environment nexus which occurs, for example, when countries intentionally modify their environmental regulatory systems by lowering environmental standards to attract more FDI or – as a counter fact – by increasing them to gain a competitive advantage in the longer term. This body of literature deals with various phenomena associated with theories, whose existence is based on the existence of the following hypothesis: 1) “pollution havens”; 2) “race to the bottom”; 3) “regulatory chill”.

2.3.1. The “pollution haven” hypothesis.

The “pollution haven” is the hypothesis which is thought to occur when investors relocate their industries in those countries characterized by weaker or even absent environmental regulation, thus gaining the maximum advantage from producing at the lowest cost in light of environmental regulatory requirements. The search for pollution havens has widely characterized the debate and the literature on the FDI-environment relationship. Still nowadays the debate on this topic is lively. In fact, the production of scientific works is still unable to empirically show systematic evidence of the existence of pollution havens, while reaching contradictory results.

Although limited to a small number of cases and specifically considered sectors, some works prove the existence of the pollution havens hypothesis (Gray, 2002)[26]. One of the earliest works on this issue refers to an investigation to assess

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In fact, in this body of literature, most of the works focus on various different aspects, such as the size, growth and accessibility of potential markets, political stability, labour costs, financial factors, mainly represented by the easy profits repatriation, red tape (administrative and legal) transparency and certainty, infrastructures, quality of life and education levels, etc. (Motta & Thisse, 1994).

[26] As made clear by some authors, the reason why a firm behaves in such a way can be better explained if we refer to the difference between the various types of FDI, which are normally divided into three types: 1) resource-seeking FDI; 2) production-seeking FDI; 3) market-seeking FDI. The first FDI category refers to those investors who aim to access critical primary resources which are not promptly available in their domestic market because of their physical scarcity or they are sold at much higher prices. For these kinds of investment activities, final outputs are rather undifferentiated. As a result, a small difference in prices can mean larger market quotas. For this reason, this type of investment flow can be very sensitive to differences in environmental costs. The second category refers to those investments made abroad in export markets to provide platforms for production and sales. A typical example can be found in the car sector when observing the way in which car producers of one country expand their network in other countries. This type of investment is not very sensitive to an increase of environmental costs. The same can

the relationship between the location of heavy-polluting industries in the United States and the dynamic of trade and investment data. No evidence confirming the existence of firms' behavioural patterns moving their investments to pollution havens in less developed countries was found in the study. This evidence was confirmed even for the case of the mineral processing sector, whose average FDI flow was much higher in developed than in developing countries (Leonard, 1988 cited in OECD, 1997). Following the same reasoning, an updated reiteration of this work was carried out by a successive study and reached the same conclusion. With specific regard to the chemical industry of three Canadian provinces, the performed regression analysis did not find any significantly evident link between environmental regulation and plant location (Olewiler, 1994 cited in OECD, 1997). In 1990 a study focusing on how regional differences in environmental regulation can affect the car industry location decision did not reach any significant evidence with the exception of those countries characterized by heavy incompliance with air quality standards (McConnell & Schwab, 1990 cited in Gray, 2002). Another survey of more or less the same period found that 26% of Maquiladora operators in Mexicali cited Mexico's lax environmental enforcement as an important reason for their location there (Sanchez, 1990 cited in WWF, 1998). A milestone often recalled in the literature refers to an analysis of the United States Direct Investment Abroad (USDIA) data in 1992. In this work, it is observed how in the considered year developing and transitional economies received 45% of the total flow. However, a very small quota of this flow (5%) went to environmentally sensitive industries, such as those related to petroleum and gas, primary or fabricated metals, and chemical sectors, while a more significant proportion (24%) reached already developed countries with tighter environmental standards. Hence, the conclusion supported the non-existence of the evidence that advanced countries export their "dirty" industries to less developed economies (Repetto, 1995). As a counter fact, another study of an American public institution reported that a number of manufacturers in the wood furniture industry moved from the region of Los Angeles to Mexico between 1988 and 1990, because here they could use their solvents without considering any air pollution constraint (U.S.

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be said for the last category of investment, whose motivation is basically the need for investors to seek new opportunities to sell in larger markets, and even in those abroad (Esty & Gentry, 1997).

Congress, 1991 cited in WWF 1998). Another study reaches a similar conclusion by using a statistical test to measure the effect of tighter environmental regulations on financial capital movement. In analysing the FDI outflow from various high and less-polluting US industries (chemicals, primary metals, electrical machinery, non-electrical machinery, food products and transportation equipments) to seven developing and 15 developed countries between 1985 and 1990, the study finds a significantly higher and positive correlation between those host countries with a more lenient environmental regulation and the US outflow of FDI. This evidence is particularly observed with regard to the chemical and primary metals sectors, which supports the existence of the pollution havens hypothesis for highly pollutant industrial sectors (Xing & Kolstad, 2002). Similar evidence comes from other studies focusing on the Chinese investment context. One of them observes how a relevant number of highly pollutant foreign firms, dealing in the pesticides and asbestos production sectors, relocated their plants to China (Guoming et Al., 1999). The other study refers how over 36% of the Chinese inflow of FDI arrived to high-polluting production sectors such as, for example, printing, dyeing and electroplating (Yofou, 1995 cited in Gray, 2002). Further examples of investment flight regarding industries involved in heavy-polluting production sectors are reported in another study. In the late eighties, firms in the wet processing and tanning industry relocated their activities from Europe to Brazil, as well as a number of firms working in asbestos tiles and benzedrine dye manufacturing facilities, which relocated to Mexico and Romania (Cairncross, 1990 cited in Gray 2002). The analysis of more recent literature seems to be more supportive of the thesis on the existence of pollution havens. By econometrically evaluating the impact of the environmental stringency on the FDI outflow of OECD countries, a significant positive correlation is found. This evidence would support the pollution haven hypothesis as related to the industrial flight dynamic, which indeed corresponds to an increase of FDI outflows when environmental stringency of countries arises (Mihci et Al., 2005). Among his various analysis focuses and conclusions, in his already-mentioned study, He (2006) provides convincing evidence of the existence of the pollution haven hypothesis. As has already been referred, he observes that the location and composition of the inward stock of

Chinese FDI are highly motivated by pursuing a "production platform" with lower compliance costs of pollution regulation. A further study proves the existence of the hypothesis in question, while analysing the pollution abatement cost savings and FDI inflows to specific "dirty" production sectors in China (Wenhuda, 2007). In the same direction, another study observes how firms in industries with higher abatement costs tend to invest more abroad to avoid high environmental compliance costs (Spatareanu, 2007).

As counterfactual evidence in a very recent analysis carried out to understand whether or not ASEAN countries can be considered pollution havens for Japanese high-polluting industries, Elliot and Shimamoto (2008) provides indication of the non-existence of the pollution havens hypothesis. In addressing the question of why the literature fails to find more evidence of the "pollution havens" hypothesis, another study suggests that the lack of a systematic and firm link between industry abatement costs and the FDI outflow from developed countries is due to the fact that most of the studies ignore the role of factor endowments in the decision of MNCs to relocate their activities abroad[27]. As is commented in the study, by focusing particularly on the link between capital intensity and pollution intensity, it is possible to identify those countries which are more likely to be considered as pollution havens. Hence, after demonstrating the relationship between capital intensity and pollution intensity of US industries and the link between the stringency of countries' environmental regulations and capital abundance, the study econometrically analyses the determinants of the US multi-sector FDI outflow to Mexico and Brazil and finds the capital sectorial requirement a key determinant for FDI location. It also finds that in US industry the abatement cost of pollution levels is a significant determinant of its FDI outflow, thus proving the evidence of a pollution haven effect (Cole & Elliot, 2005).

[27] As is commented, foreign investment, particularly that from North to South, is at least partially driven by factors endowment. Hence, it is plausible to expect that firms operating in capital intensive sectors – typically corresponding to pollution intensive industries – would invest in capital abundant countries – normally corresponding to those with stricter environmental regulations – whilst firms involved in labour intensive sectors – typically less pollutant – would invest in labour abundant countries characterized by a lenient or absent environmental regulations. This "Capital-Labour" hypothesis (KLH) seems to generate countervailing forces and dynamics with respect to those referred by the "pollution havens" hypothesis, which may explain why the literature testing the latter hypothesis fails to find systematic proof of its existence.

2.3.2. The “race to the bottom” hypothesis.

The race to the bottom hypothesis can be considered as a subset of the “pollution haven” phenomenon. In fact, it can be perceived as a possible factual evolution resulting from the recognition that “pollution havens” do matter. Indeed, it is natural to think that if the pollution haven hypothesis exists, then countries might feel that by lowering their environmental standards they would result more competitive in FDI attraction. In fact, the race to the bottom phenomenon happens when, for example, a country’s government undertake positive actions to lower its environmental standards with the final aim of bringing in FDI. Although the occurrence of this theoretical prescription may be plausible, little evidence is found to support its systematic validity.

In fact, some empirical evidence counters its theoretical foundation by highlighting that it seems unlikely that countries purposely proceed to lower their environmental standards, thus behaving in contrast to their own interest (Revesz, 1992). In addition, the existence of some factors playing the role of countervailing forces in the race to the bottom should be considered. These might be basically related to the pressure arising from local communities, whose reasoning may follow the Not in My Backyard (NIMBY) principle (Swire, 1996 cited in OECD, 2002[a]) and a number of other varying factors among which education and income levels can be seen among the most relevant aspects (Zarsky, 1999). Another study empirically testing the race to the bottom hypothesis focuses on the trends of air quality – measured in terms of suspended particulate matter – in the United States and in the three largest recipient countries of FDI in the developing world (Brazil, China and Mexico). The result shows how the globalization era has brought about a decline of the considered pollutant in major cities of all analysed countries, thus contradicting the theoretical foundation of the “race to the bottom” hypothesis. As is said, the lack of evidence is due to the fact that the basic assumption of the hypothesis in question misrepresents the political economy of pollution control in developing countries, because it does not consider a more realistic approach according to which low-income societies serve their own long-run interest by abating pollution (Wheeler, 2001).

However, counterfactual evidence confirming the existence of the “race to the bottom” hypothesis can be observed especially with regard to case studies from specific sectors. The natural resources sector could be the fact in case, especially in developing countries, where the regulatory experience may be very limited and a preference for foreign investment is often shown. In Zimbabwe, for example, the dominant presence of foreign investors in the mining sector is explained by the national “Mines and Mineral Act” which takes over any other regulation including those related to norms of environmental protection (Gray, 2002). Similar situations can also be observed in Indonesia and Papa New Guinea where, especially in the mining sector, governments have considerably relaxed environmental controls over mining operations in a range of areas. As is referred, in these two countries all mining operations are run under special conditions which require minimal or no regulation thus permitting an extensive detrimental effect on the environment. More precisely, in Indonesia mining corporations operate under special Contracts of Work (COW), thus being exempt from respecting environmental laws. Yet in Papua New Guinea, Indonesia and the Philippines, it is observed how governments have provided general or specific (project-by-project) exemptions from existing environmental and other laws with the aim of attracting higher flows of FDI (Mabey & McNally, 1998). Some further evidence in this direction is provided by other observations of the Canadian and German cases, where governments have simplified their environmental regulation by relaxing its enforcement, and implementing a more business-friendly context for investors (Esty & Geradin, 1998). Another more relevant analysis supporting the existence of the hypothesis in question refers to the Costa Rica case study, where the government actively pursued investment projects in particular polluting sectors by skipping legal requirements, also including environmental aspects. This was made by attracting FDI through the

Free Zone Law, whose implementation made the number of firms operating in the free zone context jump from 11 in 1986 to 183 in 1995 (Gentry, 1998)[28].

2.3.3. The "regulatory chill".

The "regulatory chill" can be very briefly seen as a concept very closely related to the "race to the bottom" phenomenon. It occurs when countries desist from setting stricter environmental regulations and standards with the aim of avoiding loss of competitiveness in attracting FDI (Gray, 2002)[29]. As a consequence, environmental regulation can get "stuck in the mud". More specifically, behind this idea there is the conviction that more stringent pollution control requirements impose costs which will harm the competitiveness of the eventual regulated industry. This leads economic agents – especially industrialists – to argue for lower environmental standards than would be justifiable in the absence of the problem of competitiveness. This would generate a context characterized by a lack of political consensus and support (i.e. "the political drag" effect), which plays its relevant role in the "stuck at the bottom" process and confirms the idea expressed in various models where political institutions are seen as crucial variables of this problem (Porter, 1999; Revesez, 1992). In this sense, the evidence of a recent study is supported, which analyses the relationship between environmental regulatory systems and FDI from a completely different perspective. It develops a political economy model with imperfect product market competition and where domestic and foreign firms jointly lobby the local government for the introduction of a pollution tax while also considering the

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[28] The work points out that the Free Zone Law did not set clear environmental requirements for companies entering Costa Rica and that the normative framework was confusing and incomplete. Furthermore, people working for governmental agencies involved in FDI attraction were unaware of environmental laws and norms. As a result, only two out of the 183 companies arriving in Costa Rica during that period operated under a formal environmental programme.

[29] In the case of developing countries, which are very often characterized by the inexistence of environmental regulations, this phenomenon is better known as the "stuck at the bottom" effect to mean that because of the fear of losing competitiveness in FDI attraction, they would remain "stuck at the bottom" with minimum or no environmental regulations. For example, during the last decade the governments of Morocco and Tunisia showed their unwillingness to upgrade the regulation level of the phosphate industry for the fear that the companies operating in the sector would leave their countries and relocate the activities in places with lower environmental stringency (Vogel, 1995).

corruptibility degree of the investment host countries' governments. The empirical test, a panel data for 33 countries, finds that FDI affects environmental regulation depending on the governments' corruptibility level. If the corruptibility degree is high, FDI leads to a less stringent environmental regulation and vice-versa (Cole et Al., 2006). However, as is often highlighted, the regulatory chill refers to a scenario, which is very difficult to prove since it generally refers to government inaction in undertaking appropriate environmentally protective measures in response to FDI pressure. This is indeed something very difficult to demonstrate. For this reason, this specific issue is not characterized by the existence of wide research. Nevertheless the chilling effect on regulation seems to be the most relevant effect of policy competition between and within countries rather than the race to the bottom because of the reasons explained above. Although unproven through statistical analysis, some examples of the regulatory chill phenomenon (also occurring via a political drag effect) exist and are mainly related to cases where the competition for FDI or their holding within a country has been quoted as an important reason for not introducing new environmental regulations and taxes. For example, a number of large and important corporations operating in the oil sector threatened to reduce their investments in the Netherlands as soon as the government announced a plan to introduce a carbon tax. Similarly, in response to the possibility of introducing a carbon tax in UK, the paper federation announced that in such a case its associated industries would seriously consider relocating their activities to other countries, thus leaving the UK and all the European area (Mabey & McNally, 1998). Evidence supporting the opposite situation can also be found in the literature. For example, in Mexico, following an implementation phase of environmental regulation and enforcement, a survey-based analysis on the environmental management of manufacturing firms – mostly large US companies – found they were undertaking significant investments to meet the regulation requirements and inspections. The result of this study – which considering some views in literature we may see as a sort of edge between the "regulatory chilling" and the "race to the top" or "pollution halos" theories[30] –

[30] However, it is worth highlighting that this actually clashes with the definition of the "race to the top" or "pollution halos" and seems to be more the result of a misunderstanding due to the fact that sometimes the concept of the "race to the top" theory comes out a little confused. In fact, in some

shows how less developed economies can tighten their environmental regulations without the fear that foreign investors will flee to other countries (Gentry, 1998).

As can be appreciated from the discussion above, the main point of this part of the literature on the competition for FDI and its effect on environmental standards is basically represented by the environmental cost of firms' production. Through all the hypotheses analysed, the redundant idea is that firms relocate their production to other countries to avoid higher environmental compliance costs. In these other countries, indeed, firms can take advantage either of less stringent environmental regulations – implied by the "pollution havens" and the "race to the bottom" hypotheses – or of minor costs arising from the virtuous circle related to the theoretical foundation of the "pollution halos" hypothesis, that is a cost saving as a result of the existence of higher levels of technological efficiency. Hence, in this perspective the leniency or the stringency of the environmental regulation affects the firms' production costs and, as a result, can be thought to be determinative for the location of their investment decision. However, the literature very often highlights how environmental costs do not seem to be a strong motivating factor – like those mentioned in footnote 23 – in determining the location of foreign investment. According to what is generally stated in official documents and relevant studies, environmental costs represent a very small proportion of total costs if compared to labour and capital costs, so that any difference in environmental regulation will have little impact on a firm's location decisions (i.e. Dasgupta et Al., 2001; WTO, 1998; Motta & Thisse, 1994)[31]. However, as is generally claimed, research associated to this body of literature is still lacking a deeper comprehension of how environmental regulation plays a

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works it is possible to read that the hypothesis in question occurs because a tighter environmental regulation stimulates technological advances, which promote efficiency and in turn attract investors (Gray, 2002). However, this idea should be more properly intended as the countervailing prospect of the main expectation related to the "regulatory chilling" theory, that is the existence of a weaker environmental regulation is more attractive for foreign investors. As will be highlighted, the "race to the top" or "pollution halos" hypotheses have nothing to do with the location decision of foreign investments, but with the environmental performance of foreign investors in the host country.

[31] Although this is not generally confirmed, particularly for specific sectors – as observed in the discussion above – it happens because countries commonly fail to properly price their environmental assets. According to what is broadly said in the context of environmental and natural resource economic studies, if external environmental costs are actually computed and internalized, then compliance costs would increase considerably, thus making environmental regulation a more relevant factor in the decision process of firms' investment location.

relevant role in the location of firms' investment decisions (Gray, 2002). Although some evidence confirming the theoretical thinking associated to the considered hypotheses are found both at macro and micro-level analyses, a lack of its systematic proof still risks to leave the debate at an ideological dispute among policy decision makers.

2.4. The cross-border environmental performance and the "pollution halos" or "race to the top" theory.

The third and final considered cluster of research on cross-border environmental performance of foreign investing firms goes beyond the understating of how FDI location can affect or can be affected by environmental regulation. According to some reflections, the particular consideration of the chosen environmental management approach by firms investing abroad appears to be relevant to the understanding of the environmental implication of FDI in host economies (Hansen, 1999; UNCTAD, 1999)[32]. For this reason, much of the empirical analysis developed within this cluster of research focuses more on investigating the driving forces of the different environmental behaviours and performance of foreign firms in their cross-border and relatively undifferentiated operations. In other words, it takes into account the aspect of corporate environmental performance in an attempt to understand the reason why a certain type of environmental management approach is chosen by a foreign investing firm once it has established its activity abroad in a host country[33]. This part of the literature is relevantly characterized by the "pollution halos" or the "race to the top" theory[34]. This theory assumes exactly the opposite of the "pollution havens"

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[32] As is claimed, this still appears to be a largely unexplored field. For this reason a call for further research generally exists.

[33] In this context, for example, foreign investors can opt for a wide series of strategies from those aiming to achieve significant worldwide environmental results, such as those trying to internalize global environmental costs, to those which are followed only to accomplish local environmental regulations.

[34] The "pollution halos" phenomenon is also termed the "race to the top" phenomenon or the "California effect" (Gray, 2002). The "California effect" takes its name from a specific case related to a virtuous circle which can be read in the history of American emissions standards. The Clean Air Act of 1970 gave to California – which chose this option – the possibility of undertaking stricter emission standards than those required for the rest of the US states. Later in 1990, Congress decided to bring national emission standards up to the Californian level and once again gave California the possibility of choosing a stricter emission level. At the same time, Congress

and the “race to the bottom” hypotheses and has nothing to share with the location decision of the foreign investor. It basically focuses on how the investor performs from an environmental point of view once gets into the host country, having based his investment there (OECD, 2002[b]; Zarsky, 1999). As has already been said, while the latter two hypotheses are based on the view that an inverse relationship exists between the strictness of environmental regulations and the location decision of foreign investments[35], the “pollution halos” theory is based on a different point of view. Under the “Porter hypothesis”, it could be said that stronger environmental policies would represent a comparative advantage for countries because, as a result of an over time process basically characterized by the spread of the positive implications of technological advances which promote innovation and efficiency, competitiveness (in terms of production cost reduction and improvement of product quality) would improve in the whole marketplace (Porter, 1990). In clearer terms, the idea of the “pollution halos” hypothesis is based on the premise that the existence of political and economic pressures in a “greener” country might influence environmental practices in specific sectors of another less “green” country. Of course, the main expectation at the basis of this theory is that investing firms from developed areas perform environmentally better because they hold newer and cleaner technologies as well as better environmental management systems and best-practice. This can be the result of the stricter environmental regulations existing in their home countries or even the pressure from “greener” consumers at home for their products. On the basis of the assumption that MNCs apply the same production and management systems (also those related to the environmental aspect) regardless of the country in which they operate, then the expectation is that the FDI flow they move can represent a relevant vehicle for spreading technological advances and best-practice all over the world. This theory, however, is also characterized by some weaknesses which can be synthesized in two main aspects. First of all, the literature fails to give systematic proof of its existence. Secondly, as has already been observed, the

also gave the other states the same option. In 1994, 12 states asked Congress to adopt the new standards set by California (Vogel, 1995).

[35] As has already been said, the main perception and expectation of these hypotheses is that a more stringent environmental regulation would increase production costs, reduce competition, thus making foreign investment go elsewhere.

empirical existence of the “pollution halos” hypothesis – when verified – seems to be particularly related to the energy sector (Mabey & McNally, 1998). Some studies support the existence of “pollution halos” in Mexico, Venezuela and Cote d’Ivoire where, through the use of the energy levels as a proxy of the emissions from its consumption, it is found that foreign ownership firms are associated to lower levels of energy use thus resulting environmentally cleaner (Eskeland & Harrison, 1997). Another study supporting the “pollution halos” hypothesis is related to an investigation of the investments in the field of electricity generation in China. It finds empirical evidence that, thanks to advanced technologies, foreign investments are characterized by increased energy efficiency and reduced emissions (Blackman & Wu, 1999). A number of other analyses, however, provide countervailing evidence. For example, three studies from different authors on Asian countries (Bangladesh, India and Indonesia) analysing fertilizers, pulping, paper and various other plants linked (financially or managerially) to OECD entities did not find any evidence of better environmental performance, this being associated to the scale of the plant (the bigger the cleaner) and particularly to the employment of newer technology, which is not necessarily associated to the FDI flow (Pargal & Wheleer, 1996 and Hartman, 1995 cited in Hettige et Al., 1996; Huq & Wheleer, 1993). In investigating the spending level on pollution abatement, another analysis already mentioned on the Korean manufacturing sector does not provide any evidence of the “pollution halos” hypothesis. Surprisingly, in fact, the result shows that domestic firms seem to perform better than foreign ones from an environmental perspective (Aden et Al., 1999). To conclude, a further study on the Mexican manufacturing sector does not find any significant evidence that plants linked to OECD economies through MNCs investments, trade flows, management training or management experience put much effort – this measured in terms of adoption of ISO 14000 schemes and use of plant personnel for environmental control and inspections – into improving their environmental management strategies and performance. In addition, it does not find any significant evidence that plants with new technological equipment are cleaner and perform environmentally better (Dasgupta & Hettige, 2000).

However, going beyond the detection of the studies supporting or not the "pollution halo" assumption, it is possible to observe the existence of works which identify the factors determining the environmental strategy choice of investing firms. Among the factors determining the environmental behaviour strategy, it is observed how foreign firms go from a centralized to a decentralized strategy approach depending on their size (UNCTAD, 1999)[36]. However, this is not the only determinant of the decision process, as other factors enter into the game. These can also be referred to another series of aspects such as ownership, market forces, industrial forces, and formal and informal regulatory forces. With regard to the ownership, the countervailing confirmation of the hypothesis that foreign-owned enterprises perform environmentally better than domestic ones is observable. In fact, some studies state that foreign investing firms are cleaner and more efficient in energy use and production, thus helping to reduce polluting emission levels (Eskeland & Harrison, 2003). Other studies produce evidence of the better environmental performance of foreign-owned firms. For example, an investigation of MNCs working in various sectors of the Chinese economy shows how these generate a positive environmental effect through fulfilling environmental compliances and adopting environmental regulatory schemes such as ISO 14000 (Christmann & Taylor, 2001). Different evidence is also observed in the literature, although this seems more alluded to the past. Some studies find no evidence to support the relationship between the ownership of firms and their environmental strategy and performance. This assertion is supported by a study on the reality of South and South-East Asia in which the ownership structure of firms is not found to be a significant determinant for pollution abatement (Hettige et Al., 1996). The same evidence is highlighted in other studies focusing on Mexico, where firms' environmental strategy and performance are not found to be affected by the ownership structure, but other aspects such as plant size and public environmental awareness can generate a direct effect on the firms' environmental performance (Dasgupta & Hettige, 2000). A completely different view is

[36] As is reported, although this is not always the rule, larger MNCs keep decisions on the environmental strategy approach at their centralized level. In this sense, decisions are taken directly by the foreign investor and are applied despite the country it operates in. Instead, smaller MNCs decentralize these decisions to their foreign affiliate level.

expressed in another analysis referring to the Korean manufacturing sector, in which it is observed that domestic firms perform better than foreign firms from an environmental point of view (Aden et Al., 1999). The industrial forces argument focuses on the featuring aspects of an industry. It is argued that the environmental performance of an industry depends on features such as its concentration, collaboration or collusion behaviours existing in the market system, since this will affect environmental cross-border practices among its members. Better environmental performances are more likely to occur in the case of highly concentrated industry, such as the case of oligopoly, or when a collaborative approach is followed. In the first case, firms will find themselves in a better situation to compensate environmental costs because of their higher capacity to control the market. In the second case, by following a collaborative behavioural approach, firms have greater motivation to develop common codes of conduct and to implement best practices (Hansen, 1999). A further study focuses on industrial forces by pointing out that one of the beneficial aspects of globalization is the encouragement firms receive in undertaking environmental self-regulation. This basically happens through the adoption of voluntary environmental management schemes, which often go much further than local government regulation requirements (Christmann & Taylor, 2001). The issue of market forces refers to commercial and financial featuring factors of a marketplace which can induce firms and foreign investors to implement better strategies with the aim of achieving greater environmental performance. This situation can lead to a competitive advantage in terms of positive implications in the relationship between FDI and the environment. For a better explanation of this aspect, the literature often proposes two case studies. The first regards the case of an environmental certification scheme in the banana production sector of Costa Rica, where pressure from the consumers in foreign markets and the need to produce at a lower cost led the firms in the sector – mainly of foreign investors – to reduce the use of chemicals and irrigation, thus ensuring better environmental results. The second example refers to the Brazilian pulp and paper production sector. As in the previous case, this sector is observed to have improved its environmental performance by creating a national system of certification (Gentry, 1998). The fact that customer pressure – as a featuring aspect of the marketplace – can push firms towards better environmental performance is also observed in China, where a significant quota of those producing and selling products to developed countries have higher environmental compliances and are more likely to adopt the ISO 14000 environmental schemes (Christmann & Taylor, 2001). The other market feature can be seen in the financial aspect and is related to the dynamic of the stock performance. This is an aspect which can also influence firms in the same way as has already been commented. For instance, as proven in some studies, information on negative environmental performance in poor environments harmed capital markets of countries such as Argentina, Chile, Mexico and Philippines (Dasgupta, et Al. 2001). Similarly, a case study report on the Indonesian pulp and paper industry shows how the larger producer in the sector gained enormous benefits – in terms of a significant increase of the company's stock value – from the excellent environmental improvement achieved (World Bank, 2000). More support to this view comes from a study which shows how American MNCs adopting higher environmental standards in their foreign operations than those required in domestic operations have a higher market value with respect to those not following the same strategy (Dowell et Al., 2000 cited in OECD, 2002[b])). The aspects of formal regulatory forces refer to the consideration that investing companies abroad are normally influenced by the host country regulations (O'Connor, 2000). A study already mentioned in this work, for example, observes that in Mexico, due to the existence of a good and well enforced environmental regulation, a number of American investors in its manufacturing sector generated positive technological effects, especially by bringing advanced water treatment facilities, thus ensuring a higher level of eco-efficiency in their business (Gentry, 1998). However, this observation is not always confirmed. In fact, it should also be considered that the implementation and enforcement of legal rules, especially in the environmental issue, can be particularly problematic with the result of generating very weak or null results. Evidence in this sense is particularly related to a deficiency in monitoring the respect of rules and is observed in various analyses. For example, weaknesses and enforcement problems are referred in China (Gouming et Al. 1999), Malaysia (Rasiah, 1999) and India (Jha, 1999). The existence of these difficulties would require control power to be worked out at some levels. Following the literature, it is possible to note that this could potentially be ensured by investment source countries which can set out binding environmental rules for their corporation operating abroad. Although the refection has been made and brought to light by various UNCTAD reports, no empirical work seems to have been conducted in this area, which is said to suffer from a lack of research (OECD, 2002[b]). However, when the regulatory forces of the formal sector (of both investment host and source countries) are unable to govern or to affect the environmental conduct of corporations, then it is easier that subjects of the informal regulatory forces make their appearance. As often happens, non-state actors – such as Non-Governmental Organizations (NGOs) – appear and try to cover the regulation gap by playing their role. This would be particularly aimed at implementing activities of so-called “civil regulation” – normally run in the investment source country but also in the host country – and at achieving the reduction of the environmental impact deriving from business activities through better public environmental information, that is by exposing public opinion to corporate behaviour and promoting the adherence of corporations to codes of responsible business conduct (Newell, 2001).

As is clear, this final body of literature considering the cross-border environmental performance of foreign firms actually focuses on what is also known as corporate environmental performance. In recent years, this has become a relevant public issue with respect to the situation of both developed and developing countries. Research does not yet properly explain why cross-country differences of MNC environmental performance is observed. As is generally referred, this can be due to the lack of appropriate data and more comprehensive knowledge linked to the fact that the release of information on the environmental aspects of the operation of foreign firms abroad still remains a voluntary fact. As the search for public consensus pushes firms to release environmental reports of their activities, more information will become available for additional investigation in this area of discussion. This will help to better understand the role and relevance that firms’ features (as endogenous drivers) and market, industry and regulatory forces (as exogenous drivers) have on their environmental performance in both domestic and foreign countries.

2.5. Remarks and conclusions.

By referring to the scientific literature produced so far and we are aware of, in this chapter we have introduced and discussed the main issues of the relationship between FDI and the natural environment. Our literature review is exhaustive of the different views developed by research and analysis developed in this thematic context which basically refers to three main discussion areas: 1) the environmental effects of FDI flows; 2) the competition for FDI and its effects on environmental standards; 3) the cross-border environmental performance.

As we have more extensively reported in the chapter, the first vein of discussion includes those works which attempt to understand if FDI flows generate benefits and costs or opportunities and risks for receiving countries. These works basically focus their attention on the effects FDI generates on some specific aspect of the host countries' economy. More specifically, the subject of their investigation is the identification and quantification of technique, scale and composition effects. While the technique effect refers to the change of the production methods as a result of the development and diffusion of technology, the composition effect is associated to the result deriving from the change of the industrial structure of an economy as a consequence of a reallocation or reorganization of the production and consumption structure. The scale effect refers, instead, to the result of the expansion of the economic output (OECD, 2002[b])[37].

The second theme refers to those works focusing their research and analysis effort on two different aspects which appear as the two sides of the same coin: the impact of environmental standards on the location of firms' investment decisions and the environmental effects of international countries' competition for FDI. Research on the first aspect attempts to understand if the existence of countries

[37] As has been adequately highlighted and argued in the dedicated part of this chapter, the contemporarily consideration of the technique and scale effects implicitly brings the EKC issue with itself.

with different environmental regulations and standards can be a reason for firms relocating their activity. The second aspect is the subject of those works analysing the implication of the FDI-environment relationship which occurs, for example, when countries intentionally lower their environmental standards to attract more FDI. As has been adequately reported, the literature produced in this context of analysis has brought the following hypothesis deals with various phenomena associated into light as a result: 1) "pollution havens"; 2) "race to the bottom"; 3) "regulatory chill" (i.e. He, 2006; Cole & Elliot, 2005; Grey, 2002).

The third and final vein of discussion goes beyond the understating of how FDI location can affect or can be affected by environmental regulation. It builds its research interest on the consideration of the chosen environmental management approach by firms investing abroad, since this appears to be relevant to the understanding of the environmental implication of FDI in host economies. This part of the literature is relevantly characterized by the "pollution halos" or the "race to the top" theory, which assumes exactly the opposite of the "pollution havens" and the "race to the bottom" (i.e. Hansen, 1999; UNCTAD, 1999; Porter, 1990).

It is in the first thematic area where we find our inspiring motivation and which all our empirical work, developed in the next chapter, refers to. In fact, the relationship between FDI and the environment is generally claimed to be one of the research areas where a lack of better and more appropriate scientific understating exists. This is particularly true if the context of analysis associated to this first vein of discussion is taken into consideration. Apart from the fact that the relationship between trade and investment has more often been subject of investigation, rather than that between FDI and the environment, the scientific literature produced insofar could be perceived as not completely exhaustive. In fact, works in this field can be grouped into two main veins. The first vein, particularly developed between the late 1990's and the beginning of the 2000's, numbers among its major studies those works focusing on the individual analysis of each single aspect playing a role in the FDI-environment relationship, namely technique, scale and composition effects. Only more recently, starting from the late-mid 2000's a new analysis approach, based on the contemporary consideration of the mentioned effects – that is on the decomposition of the environmental effects of FDI into scale, technique and composition effects – was developed on the consideration that FDI does not occur as an isolated phenomenon, which only affects the environmental sphere, but it also interrelates with other linked factors (OECD, 2002[b]). To our observation, however, even the more recent literature is characterized by some methodological failures, since it misses to carry out empirical analysis with reference to specific sectors. Apart from some recent work (e.g. Ben Kheder, 2010), empirical investigation takes into consideration aggregated values of FDI flows and polluting agents disregarding the specific dynamic observable at the level of each specific activity sector. With the aim of overcoming this situation, which in our view represents a heavy limitation to the development of more appropriate empirical analysis, in the next chapter of this work we present empirical investigations in which the FDI flows and the pollutant agents are considered in strict association to the economic sector investigated time by time. More specifically, the next chapter presents empirical investigations conducted on the basis of the sectoral breakdown ("agriculture and fishing", "manufacturing" and "transport and communication") of both FDI flow and polluting agents typically generated in each considered sector. The analyses take into consideration OECD countries because – apart from the fact that countries belonging to this aggregation are more dynamic in attracting FDI – the OECD database is the only one containing the statistical information of FDI flows organized in terms of sectoral breakdown.

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CHAPTER III

Empirical Evidence from Sectoral Investigations

3.1. Introduction.

As has already been said in the previous chapter, studies on the FDI-environment relationship can be divided into three main veins of discussion: 1) the environmental effects of FDI flows; 2) the competition for FDI and its effects on environmental standards; 3) the cross-border environmental performance.

It has also been highlighted that the theme related to the environmental effect of FDI is said to be a still largely unexplored research area and calls for further research (McAusland, 2008; OECD, 2002[b]). In our view, this is even truer when this argument is treated at the level of specific economic sector of activity. The majority of research carried out so far has largely focused on the macro-aspects of the link between FDI and some considered pollutants by investigating data aggregated at country level (i.e. Shabbaz et Al., 2011; Liang, 2006). Minor attention, instead, has been paid to investigate the issue while considering the features of specific sectors of economic activity. There is very little research in this sense and it is still far from giving us a clear understanding of the phenomenon. It is on this last consideration that our research interest finds its foundation. However, before entering the core aspect of this chapter, which is devoted to the empirical task of our work, we would like to very briefly recall some aspects already treated in the previous chapter. The aim is to refresh some main concepts of the theory characterizing the theme of environmental effects of FDI and to better prepare for the reading of the analysis which will be developed in the following sections.

As already said in the previous chapter, FDI does not affect the environment as an isolated phenomenon since it also interacts with a range of other linked factors. For this reason, various analyses have carried out their work by decomposing the environmental effects of FDI into technique, scale and composition (or structural) effects (i.e. He, 2008; Liang, 2006; He, 2006; Cole &

Elliott, 2003; Grossman & Krueger, 1995; 1993[a]; 1993[b]; 1991)[38]. In short, the technique effect refers to the change in the production method – this involving development, transfer and diffusion of technology and/or introduction of regulation – deriving from an economy's growth process which, among other things, can be induced by FDI inflow. The scale effect refers to the increase in the size of the economy[39]. Lastly, the composition (or structural) effect is associated to the change in its industrial structure occurring as a shift in the pattern of economic activity. Broadly speaking, a discussion on the environmental implication of these three types of effect we have just mentioned generally hypothesizes that the technique effect is almost always associated to the fact that, in a given country, the quantity of emissions per unit of considered goods produced or consumed depends on their production or consumption "techniques". Due to a mechanism of allocative efficiency among countries, which implicitly exists in the free movement of investment, liberalization can very likely change these techniques especially through policy and technological channels. More specifically, as growth and income increase, the demand for environmental quality also increases. This leads to the generation, in the considered economy, of a new demand for products based on more "environmentally-friendly" technologies and/or for the enforcement of environmental regulation policies. In other terms, the technique effect generally refers to the development, introduction and diffusion of new and more stringent environmental regulations and more efficient technologies, which are expected to exert a beneficial role on the environment.

The scale effect, instead, is expected to generate a detrimental result deriving from the fact that an increase in the size of an economy implies more

[38] These terms, which now belong to standard economic terminology, were entered in the economic literature after they were used by Grossman and Krueger in their seminal work of 1991, where they analysed the environmental impact of trade liberalization within the context of the NAFTA agreement (Grossman & Krueger, 1991). Although these terms were coined in relation to trade, they are also used for the case of FDI studies. This makes sense if we think that trade and FDI are the two faces of the same coin due to the strong correlation existing between them and proven by various studies (e.g. Ghosh, 2007; OECD, 2002[b]).

[39] It is the case to highlight that, although theoretically different, "technique" and "scale" effects appear very similar. In fact, they are quite difficult to separate especially with regard to their consideration in empirical analysis. As will be clarified later in the section where the models subject of our analysis will be presented, the "technique" effect is identified by the only variable of GDP taken in isolation. The "scale" effect is identified by two variables contemporarily considered, namely the GDP per-capita and its squared computation.

production and, in turn, more pollution. More specifically, as a result of an economic liberalization process, the more efficient allocation of resources within countries modifies the frontier of production possibilities. This raises the size of the industrial pollution base and results in greater global emissions. However, it must be highlighted that the scientific discussion on the scale effect contains the EKC argument in itself. Various studies have observed how the expectation of environmental deterioration, associated to the scale effect, can be verified up to a certain point or level of an economic growth process. Afterwards, an amelioration of the environmental situation can be achieved because as countries become richer the ability of adopting new and more efficient technologies (together with people's sensitiveness in requiring more stringent environmental regulation) increases. However, looking at the literature, we are aware of the number of different viewpoints the empirical investigation on this topic has generated (e.g. Stern, 2004[b]).

Finally, with regard to the composition effect, the environmental implication is generally expected to be beneficial to the environment on the assumption that the already mentioned free movement of investment encourages allocative efficiency among countries (OECD, 2001). As a result of an economic liberalization process, the lowering of tariff and non-tariff barriers reduces the relative prices of import-competing goods. Such a dynamic might induce, for example, the service sector (less polluting) of a considered country to expand and the industrial one (more polluting) to shrink. The outcome is that its total emissions will likely fall with a beneficial result for the environment. However, this view is not subject to general agreement. Other works highlight how, in a free trade and investment context, the expected sign of the impact resulting from the composition effect can be positive or negative depending on the productive specialization of a country. This, of course, depends on the country's competitive advantages, which can be characterized by opposite sources (Cole & Elliott, 2003).

Having done this, we are now ready to move further and talk about the rationale of this chapter. For the reasons referred in the opening of this section, the aim of our work is to contribute towards covering the gap still characterizing research on the issue of the environmental effect of FDI. To this end, our research focuses on a sectoral level and we investigate three specific sectors of activity ("agriculture and fishing", "manufacturing" and "transport and communication") of the OECD countries[40] to determine whether and how the sectoral inflow of FDI has an impact on their natural environment and, especially, on the levels of some specifically considered pollutants.

As a consequence, the organization of this chapter is as follows. The next section is devoted to a general presentation of the materials and methods used for our empirical analysis. A further section is dedicated to the analysis of the "agriculture and fishing" sector. More specifically, while the introductory aspects of the analysis are treated in the main body of the section, the presentation of the two econometric models used (one to assess the relationship between the sectoral inflow of FDI and CH_4 and the other to do the same with CO_2), comments on the estimation results and the final conclusions together with a discussion of the resulting policy implications are articulated in the subsections. In another section, the "manufacturing" sector is analysed and, once again, the specification of the model used, the presentation of its results and the concluding considerations together with the associated policy implications are articulated in subsections. A similar structure is given to the last section of this chapter, where the "transport and communication" sector is analysed.

3.2. The materials and methods of the empirical analyses.

As has already been anticipated, our investigation of the FDI-environment relationship is conducted while considering specific sectors of economic activity of the OECD countries. More precisely, our empirical analyses, which will be

[40] The 30 OECD countries are: 1) Australia; 2) Austria; 3) Belgium; 4) Canada; 5) Czech Republic; 6) Denmark; 7) Finland; 8) France; 9) Germany; 10) Greece; 11) Hungary; 12) Iceland; 13) Ireland; 14) Italy; 15) Japan; 16) Korea Republic; 17) Luxembourg; 18) Mexico; 19) The Netherlands; 20) New Zealand; 21) Norway; 22) Poland; 23) Portugal; 24) Slovak Republic; 25) Spain; 26) Sweden; 27) Switzerland; 28) Turkey; 29) The United Kingdom; 30) The United States of America. The remaining four OECD countries (Chile, Estonia, Israel and Slovenia) are not taken into consideration, because their accession only took place in 2010. At the last visit made in November 2011, the OECD database within the ESDS International statistical support tool (which is the only database available reporting data on the sectoral breakdown of FDI), does not yet report information on these countries, since it is based on the “OECD international direct investment statistics (vol. 2010, release 01) with updates at 2007.

presented in the next three sections, closely look at three sectors ("agriculture and fishing", "manufacturing" and "transport and communication") to verify whether and how the FDI inflow impacts the level of specific pollutants particularly associated to each considered sector. With regard to this, the polluting agents taken into account in our analyses are methane (CH_4) and carbon dioxide (CO_2) from the sectoral fuel combustion for the case of "agriculture and fishing". The sectoral amount of CO_2 from fuel combustion is also considered for the "manufacturing" and the "transport and communication" sectors. It is important to stress that this sectoral approach of analysis is an innovative contribution to the issue under consideration. In relation to the temporal aspect, our analyses take into consideration the period between 1981 and 2005 with the exception of one of the two analyses devoted to the "agriculture and fishing" sector. More specifically, the investigation of the FDI-CH_4 relationship focuses on the period between 1990 and 2005 due to a more limited historical series of CH_4 data.

On the basis of the information above and to the purpose of our empirical task, we have built a panel datasets by sourcing statistical information from the databases of various international organizations[41]. The panel dataset covers observations for 30 countries, for 25 years (16 years for the investigation of the FDI-CH_4 relationship in the "agriculture and fishing" sector) and contains 24 different variables. However, it must be noted that the number of observations actually subject of the analyses is smaller than one expects considering the described main features of the dataset. As will be seen in the sections devoted to the presentation of the analyses results, depending on the informative base of each considered sector, the number of observations actually analysed varies from about a third to about a quarter of the total number of observations one would expect (750 and 480 for the case of the analysis of the FDI-CH_4 relationship in the "agriculture and fishing" sector). In fact, the statistical gaps in the source

[41] We are aware of the fact that the “Centre d'Etudes Prospectives et d'Informations Internationales” (CEPII) recently developed a FDI database covering 96 countries (for FDI stock data) and 70 countries (for FDI flow data) as at 2004. Among the most relevant features of this database, we can note that it considers a breakdown of the FDI flow and stock into 26 activity sectors. However, we were unable to use it for our investigation because - as explicitly stated in the CEPII webpage - the methodology used to construct missing data and to balance the dataset makes it inappropriate for econometric analysis (http://www.cepii.fr/anglaisgraph/bdd/fdi.htm).

databases deeply characterizes our panel dataset which - according to Greene (2012) - is as a result defined as strongly unbalanced.

With regard to other aspects, our analyses are carried out by employing the econometric technique of panel-data since they are characterized by country and time units. In addition to the fact that this technique is also suitable for unbalanced panel datasets, which however benefit from its analysis property, it must be highlighted that the panel data technique shows the advantage of checking for unobserved heterogeneity, which is a form of omitted variable bias, and investigating dynamically over time. Apart from those problems associated to heteroskedasticity, autocorrelation, stationarity and cointegration (for which the data in our model specifications have been checked with appropriate tests and whose result will be reported in the next section together with the estimations result), the panel data technique also shows the advantage of reducing the problem related to the existence of collinearity among variables, which allows the achievement of more precise estimates generated by the efficiency gain resulting from the higher quantity of data which can be considered with respect to other techniques such as cross-section and historical time series analysis (Greene, 2003; Woolridge, 2000; Gujarati, 1995).

Regarding the specification of the relationships subject of analyses, in this section we only report the equation in a generic form and postpone a more detailed presentation of it to the sections where the analysis of each considered sector will be treated[42]. Broadly speaking, with the aim of achieving coefficients representing the elasticities of the relationships subject of investigation, the functional form we use for our estimations is in log-log terms[43] and defined by the following expression:

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[42] It is the case to highlight how, in relation to graph 1.1 in the previous chapter, the baseline specification we propose here refers to an analysis of the macro effects of FDI. As will be seen later in the specific sections where the variables subject of investigation are explained, FDI is considered in terms of provision of capital flow. Although its data is gathered in relation to some specific sectors ("agriculture and fishing", "manufacturing" and "transport and communication"), FDI is not treated here as a variable concerning structural changes in the economic and industrial organization of the considered countries and, therefore, it does not account for micro effects.

[43] We recur to the use of a log-log form due to the presence of exponential series in our model and also because - as will be seen later - the regressors in our models are expressed in different units of measurement. The elasticity then becomes a more objective measure since it allows to quantify the relationship between the dependent variable and the independent variables in percentage terms.

$$Y_{it} = \alpha + \beta_1 \, GDPsctr_{it} + \beta_2 \, GDPsctr^2_{it} + \beta_3 \, FDIsctr_{it} + \beta_4 \, FDIsctr^2_{it} + \beta_n \, X_{it} + \varepsilon_{it}$$

where: *i* represents the country or cross-sectional unit and is associated to the 30 OECD countries under our consideration; *t* is the time unit referring to the number of years considered; *Y* is the sectoral pollutant which will vary, of course, depending on the sector under investigation; *GDPsctr* and $GDPsctr^2$ are the sectoral Gross Domestic Product in real terms and its squared form respectively and, as will be specified later in the sections devoted to the empirical analysis, they are employed either in per-capita or per-worker terms to identify the induced-GDP technique, scale and cumulative effect; *FDIsctr* and $FDIsctr^2$ respectively represent the sectoral FDI inflow and its computation in squared terms. Similarly to before, they are considered in real terms and indicate the induced-FDI technique, scale and cumulative effects; *X* is a generic vector of other variables which will be better defined later in the sections devoted to the analysis of each considered sector where the functional relationships will be more specifically identified; ε is the error term.

Before concluding this section, however, it is useful to explain how the induced-GDP and the induced-FDI technique, scale, cumulative and composition effects are identified in the above generic equation model.

According to Cole and Elliot (2003), the induced-GDP technique effect is identified through the estimated coefficient of the GDP variable taken in isolation, since it happens as a result of a change in the income level and tells us how the dependent variable changes (in percentage terms) when GDP changes by 1%. The induced-GDP scale effect is, instead, represented by the GDP squared variable since it represents the size of a country’s economy and its enlargement. More specifically, the scale effect is achieved by computing the partial derivative of the above equation with respect to GDP so that what appears in the generic equation as $\beta_1 \, GDPsctr + \beta_2 \, GDPsctr^2$ turns into $\beta_1 + 2\beta_2 \, GDPsctr$. The elasticity of the scale effect is then observed only through $2\beta_2$. Its environmental-economic meaning tells us how the dependent variable changes (always in percentage terms) in response to the 1% GDP change (e.g. He, 2008; Liang, 2006; Cole & Elliott, 2003; Antweiler et Al., 2001)[44].

The contemporary consideration of the technique and scale effects allows us to compute the cumulative (or total) effect which is, indeed, achieved through the algebraic sum of the terms resulting from the partial derivative of the model equation with respect to GDP. In other words, the coefficient is represented by the betas in $\beta_1 + 2\beta_2\, GDP$ and its environmental-economic meaning indicates the change (in percentage terms) of the dependent variable as GDP varies by 1%. Its actual impact can be computed while considering, for example, the sample mean income of OECD countries as *GDP* (e.g. Managi et Al., 2008).

Similarly, the induced-FDI effects on the considered environmental dependent variable can be observed as follows. The technique effect is associated to the variable of the FDI sectoral inflow taken in isolation. As a consequence, it can be observed through β_3 in the above equation model, that is the estimated coefficient of the FDI variable. The induced-FDI scale effect is determined through $2\beta_4$ resulting from $\beta_3 + 2\beta_4\, FDIsctr$ that is the partial derivative with respect to FDI of $\beta_3\, FDIsctr + \beta_4\, FDIsctr^2$ in the above equation. The cumulative effect is finally represented by the contemporary consideration of the coefficients of the technique and scale effects, namely $\beta_3 + 2\beta_4\, FDIsctr$, and can be computed while substituting *FDIsctr* with the sample mean of the sectoral FDI inflow in OECD countries. Of course, the environmental-economic meanings of the results of the induced-FDI effects are identified in the same way as done for the induced-GDP ones[45].

[44] In other relevant works (e.g. Antweiler et Al., 2001), scale and technique effects are separately measured by employing two different identities. While the earlier is measured in terms of GDP per squared km., the per-capita GDP is used for the latter. As will be seen in the specific sections, following Cole and Elliot (2003) – who use per-capita GDP to capture both the effects – we employ the sectoral GDP per-worker (in the case of the "agriculture and fishing" and "manufacturing" sectors) and the GDP per-capita (in the case of the "transport and communication" sector). The GDP per squared km., also tried in our analyses, came out insignificant. It must be noted that transformations of the above-mentioned GDP variables in cubic terms resulted insignificant and reduced or invalidated the significance of other variables in the estimated models.

[45] Similarly to what said in the previous footnote, in our analyses we consider the FDI variable in per-GDP terms (in the case of the "agriculture and fishing" sector) and per-worker in the sector (in the case of the "manufacturing" sector). For the "transport and communication" sector we employ the FDI variable expressed in terms of per-squared km. Even in this case, the transformation of the FDI variables in exponential terms beyond the squared form was not statistically significant.

The composition effect, which does not appear straight in the above generic equation form because considered in the generic vector of variables X, is captured in our models by considering a variable representing the relevance of our investigated sectors. In our modelling, this is given by the ratio between the sectoral GDP and the total.

Having noted these methodological aspects, we are now ready to move onto presenting the specific cases of analysis which will be the content of the next three sections.

3.3. The analysis of the "agriculture and fishing" sector.

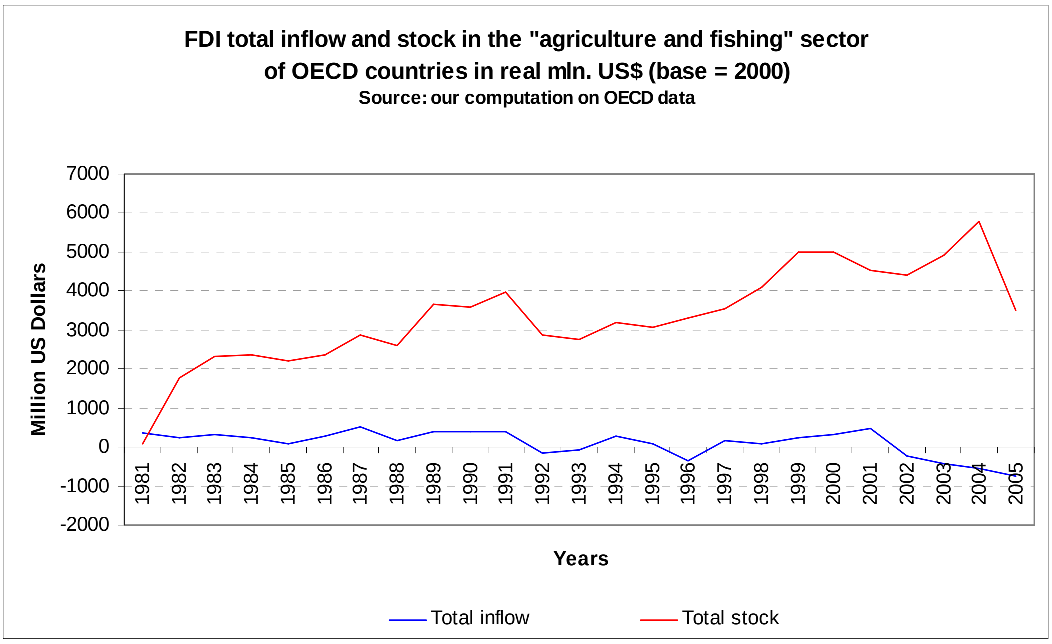
To present the sector, we can say that computations made on the basis of our available United Nations data enable us to observe that “agriculture and fishing” is one of the most relevant economic sectors in the OECD considered area. It accounted for about 23.4% of the total GDP at the first year (1981) of our considered period. Although it decreased in 1993 to 14.94% and to 11.41% in 2005, this sector still remains a relevant contributor to the considered countries’ economies.

However, with the aim of orienting the discussion developed in this section to the purpose of our analysis, we proceed by analysing the trends of the main variables subject of our empirical investigation. More specifically, the sectoral FDI flow and stock are analysed over the period between 1981 and 2005. In addition, methane (CH_4) is considered in the time span 1990-2005 and emissions of carbon dioxide (CO_2) from the sectoral fuel combustion between 1981 and 2005.

With regard to FDI, the graph below (graph 3.1) shows the trends of its inflow and stock (or inward position) derived from the year by year data aggregation in the 30 OECD countries (see tables III.1 and III.2 in the appendix section). Despite some difficulties in observing this data, as a result of various gaps in the source databases, we can see how over the considered period the trend of the inflows has generally decreased after fluctuating in a range varying between a maximum of +527 million US$ (recorded at 1987) and a minimum of about -736 million (at 2005 when evidently the amount of disinvestment overtook the investment). The observation of the aggregated data by country shows how the country which received the major investment quota is Spain (with a total of about 1,472 million US$) for all the considered period. It is followed by USA (with about 783 million US$) and Italy (with about 595 million US$). The countries which, between 1981 and 2005, experienced major levels of disinvestment, instead, are: Belgium (with about -2,139 million US$) and Germany (with about -1,528 million US$).

The observation of the trend of the FDI stock, analysed of OECD aggregated data, shows a substantial – although fluctuating – increase from about 74.5 million US$ in 1981 to about 3,492 million US$ in 2005. As can be observed in table III.2 in the appendix, the years in correspondence with the major levels of stock capitalization recorded are: 2004 (with about 5,798 million US$); 1999 (with about 5,005 US$) and 2000 (with about 4,983 US$). The analysis of the stock dynamic by country enables us to observe how, during the period between 1981 and 2005, the USA and Australia are the two countries, which received the highest amount of FDI. In fact, the earlier shows a total stock of about 44,068 million US$, the latter about 18,184 million US$. They are followed by the United Kingdom (with about 4,280 million US$), Mexico (with about 4,086 US$) and Italy (with about 3,834 million US$).

Graph 3.1



With regard to the pollutants subject of our analysis, we focus our attention on CH_4 and CO_2 because – as will be better explained later – the first is strictly related to some typical production activities of the “agriculture and fishing” sector. The second, whose dataset is available thanks to estimates provided by the International Environmental Agency (IEA), is here considered in relation to the activity of fuel combustion specifically occurring in agriculture and fishing. A further reason for this choice lies in the fact that they are available in a larger and more complete dataset with respect to other pollutants. Apart from their wider availability, however, there are other valid reasons at the base of their choice. Relevant studies state that CH_4, together with CO_2, N_2O (Nitrous Oxide) and halocarbons (which is a group of carbons containing fluorine, chlorine or bromine), is among the four long-living Greenhouse Gases (GHGs) and, as a result, the second largest contributor to global warming and climate change (IPCC, 2007).

Like any other GHG, it occurs as a natural phenomenon (being a primary component of natural gas and the result of the existence of wetlands and deposits lying on the ocean floor) as well as the result of running human activities. With regard to these, CH_4 represents something between 14.3% and 15% of global anthropogenic GHGs emissions and is generated from landfills, waste management, and energy production (coal, oil and natural gases extraction and processing). In particular, agricultural activities such as rice paddies cultivation, livestock and manure management are considered among the most relevant anthropogenic sources of CH_4. The activities of livestock and manure management are particularly considered as the second largest contributors to its generation (EPA, 2011; Jorgenson & Birkholz, 2010; World Bank, 2009; IPCC, 2007)[46]. Although agriculture is the aspect which is always called to the bar when talking about CH_4 emission sources, here it is the case to very briefly highlight how a relationship with fishing might also exist. Some relatively recent research work discusses how the deterioration of marine ecosystems caused by the loss of

[46] Some studies also highlight how CH_4 is more than 20 times as effective as CO_2 at trapping heat in the atmosphere (EPA, 2011). Furthermore, other relevant analysis report that between 1981 and 2005 the CH_4 concentration in the atmosphere increased by 148% (IPCC, 2007).

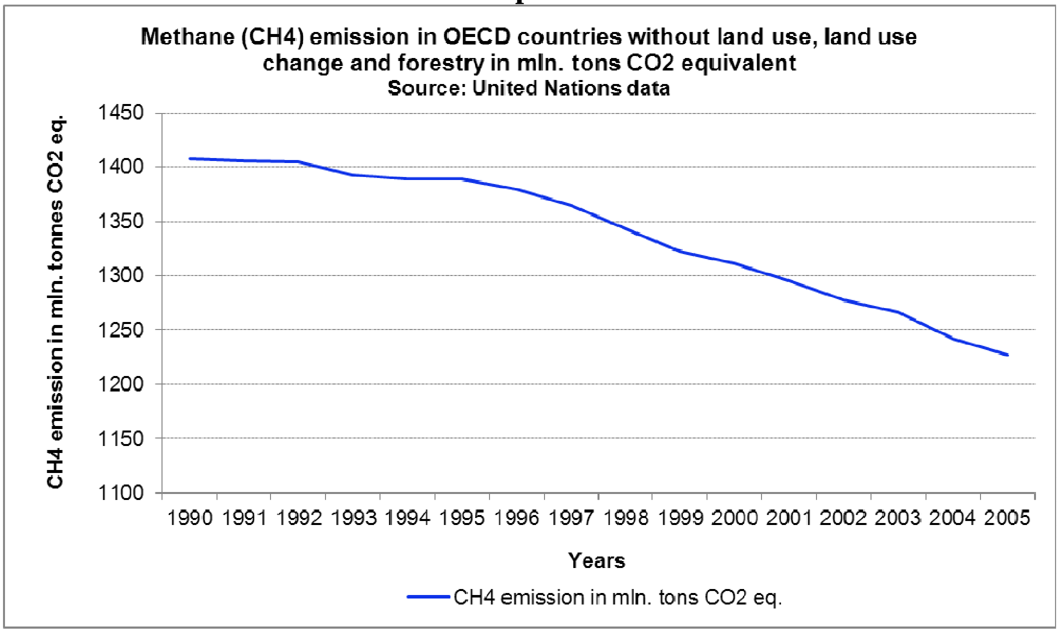
specific fish species – due to heavy industrial fishery – is very likely to contribute to the increase of GHGs and, particularly, of CH_4 (Bakun & Weeks, 2004).

In relation to the other pollutant (CO_2) and apart the straight link with sector in analysis due to the fact that it is considered in terms of emissions deriving from those sectoral activities whose operations are based on fuel combustion, we can identify other possible links to fishing similarly to what has just been stated for methane. Some studies report how the removal of marine biota – basically occurring through uncontrolled fishing activities, which always results in heavy marine resources exploitation – would increase the almost unknown atmospheric Carbon dioxide (pCO_2), which implies an increase of CO_2 (e.g. Fashman, 1993; Shaffer, 1993). For other aspects, with regard to the identification of links between CO_2 and agriculture, we must observe how this relationship is fundamentally based on deforestation (quite often caused by the expansion of agriculture to the expense of forested areas) and biomass burning (Fernandes & Thapa, 2009; World Bank, 2009).

An analysis of the trends related to the pollutants we take into consideration (CH_4 and CO_2 from the sectoral fuel combustion) enable us to observe the following. With regard to CH_4, first of all it must be highlighted that the set of data stored in the United Nations database did not give us the possibility of going any further back than 1990. Furthermore, the CH_4 data considers the emission level generated without land use, land use change and forestry. As the graph below (graph 3.2) shows, by looking at the year by year aggregated data of CH_4 emissions, we can observe an almost constant decrease in the OECD area between 1990 and 2005 (see table III.3 in the appendix). In fact, the total amount of CH_4 emission in the OECD area was about 1,407 million tons CO_2 equivalent in 1990 and shifted down to about 1,226. For other aspects, the analysis of the breakdown by country shows that, between 1990 and 2005, countries such as the USA (with about 9,157 million tons CO_2 equivalent), Australia (with about 1,836 million), Canada (with about 1,468 million) and the United Kingdom (with about 1,255 million) were the major polluters among the OECD countries. Iceland (with 7.24

million tons CO_2 equivalent), Luxembourg (with 7.58), Switzerland (with 62.04) and Norway (with 77.14) were, instead, the lesser polluters[47].

Graph 3.2



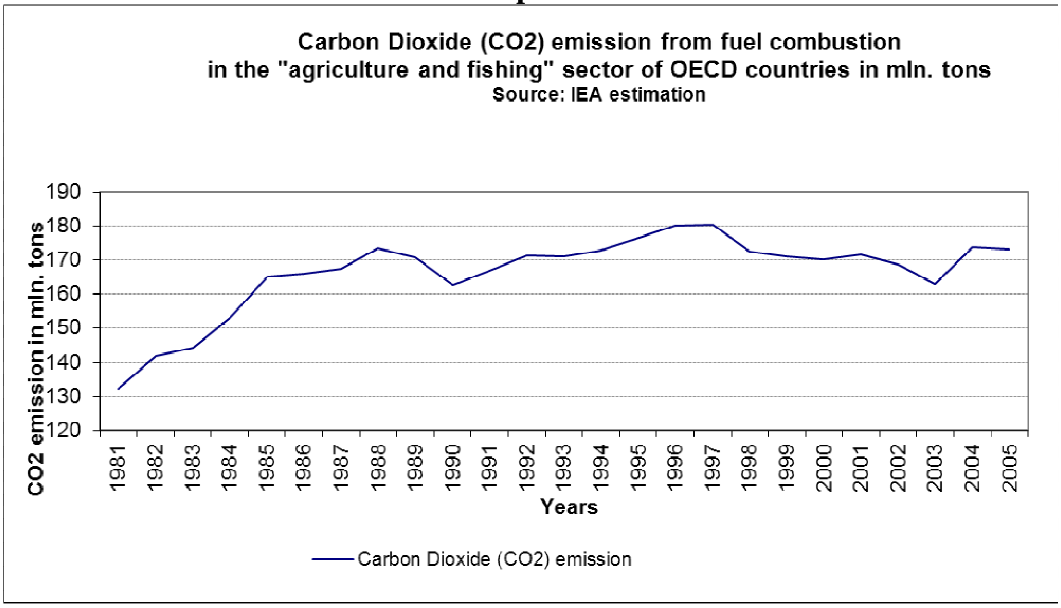
A different story can be reported for CO_2 which, as has already been pointed out we consider in terms of amount of CO_2 specifically deriving from the fuel combustion in the "agriculture and fishing" sector. As shown in the graph below (graph 3.3), which is built on data estimated by the International Energy Agency (IEA) and reported in table III.4 in the appendix, we can observe an increase of the sectoral CO_2 emission from 132.8 million tons in 1981 to 173.04 in 2005, although fluctuations can be seen during all the considered period.

Here again, moving onto analysing the breakdown by country we can see how, during the whole 25-year period we are considering, the USA was the major polluter of CO_2 from fuel combustion activities in the "agriculture and fishing" sector with about 1,108 million tons. It was followed by Japan (with about 491 million tons), Poland (with about 256 million tons), France (with about 231 million tons), Canada and Italy (with about 192 million tons each) and The

[47] It is interesting to note that, if we stop our observation at 2005 – the last year considered in our analysis – and normalize the emission quantities on the basis of the population, the major CH_4 polluting countries become New Zealand (with about 6.66E-06 million tons of emissions per capita), Australia (with about 5.60E-06), Ireland (with about 3.20E-06) and Canada (with about 3.16E-06).

Netherlands (with about 178). Minor polluting countries are Luxembourg (with 0.56 million tons), Switzerland (with 6.87), Ireland (with 14.92), Iceland (with 16.87) and New Zealand (with its 22.40 million tons)[48].

Graph 3.3



3.3.1. The modelling strategy description.

The investigation of the impact FDI arriving into the "agriculture and fishing" sector of OECD receiving countries generates in their natural environment is run through two different equations because - as has already been said - two pollutants (CH_4 and CO_2 from the sectoral fuel combustion) are considered for the analysis of this specific sector. As has already been anticipated in the second section of this chapter, the panel dataset built for the analysis of the sector in question contains 24 variables which have all been tried in the numerous analysis attempts aimed at attaining the best fit of the estimated models. Of course, some of them have only been found statistically relevant to explain the investigated relationships. To make for easier reading, we introduce the table below (tab. 3.1) where a schematic specification is reported.

[48] As before, if we stop our analysis at 2005, and normalize the emission quantities on the basis of the population, we can observe how the major polluting countries are: Iceland (with about 2.39E-06 million tons per capita), The Netherlands (with about 5.19E-07), Norway (with about 3.77E-07), Denmark (with about 3.39E-07), Poland and Finland (with about 3.24E-07 each).

Tab. 3.1 – Variable specification for model [1] and model [2][49]

No.	Variable	Description	Source
1	CH_4 Dep. var. in model 1	Natural log. of the ratio between the amount of Methane (in Gg. CO_2 equivalent) and the population amount.	Our computation on UN data
1 bis	CO_2sctr Dep. var. in model 2	Natural log. of the ratio between the amount of Carbon dioxide (in million tons) from fuel combustion in the sector and the amount of population.	Our computation on IEA estimation and UN data
2	GDPsctr (in model 1 only)	One year lag of the natural log. of the ratio between the sectoral GDP (in real US$) and the amount of workers in the sector.	Our computation on UN/OECD data
2 bis	GDPsctr (in model 2 only)	Natural log. of the ratio between the sectoral GDP (in real US$) and the amount of workers in the sector	Our computation on UN/OECD data
3	$GDPsctr^2$	(1lag_ln GDPsctr * 1lag_ln GDPsctr) square of the natural log of the sectoral GDP per worker in the sector (in real US$).	Our computation on UN/OECD data
4	FDIsctr	One year lag of the natural log. of the ratio between the sectoral FDI inflow[50] (in real mln. of US$) and the GDP (in real US$).	Our computation on UN/OECD data
5	$FDIsctr^2$	(ln FDIsctr * ln FDIsctr); square of the natural log of the sectoral FDI inflow (in real mln. of US$) per GDP (in real US$).	Our computation on UN/OECD data
6	SCTRrel	Natural log. of a sectoral relevance indicator given by the ratio between the sectoral GDP (in real US$) and the total GDP (in real US$).	Our computation on UN data
7	MKTopn	Natural log. of a market openness indicator given by the ratio between the amount of export f.o.b. (in real US$) and the total GDP (in real US$).	Our computation on IMF/UN data
8	EDU	Natural log. of the average year of school indicator.	Our computation on CID Harvard data
9	CATTLE (in model 1 only)	Natural log. of the no. of cattle per squared Km.	Our computation on WB/FAO data
10	PROTarea	Natural log. of the surface of protected area (in squared Km.).	Our computation on UN data
11	CRpr	Cross-product derived from the product between the natural log. of the sectoral GDP per worker in the sector (in real US$) and the natural log. of the total FDI inflow per GDP (in real mln. US$).	Our computation on UN/OECD data

With regard to the specification of the two functional relationships subject of analysis, we have already said that they are expressed in log-log terms and now clarify that they take the form of the following two equation models:

[49] All the financial data in our database is in US$ and transformed from current to real terms by using the USA Gross National expenditure Deflator (base year = 2000) gathered from the World Bank (World Bank database at http://databank.worldbank.org).

[50] According to what has been said in the previous chapter and other empirical works, we focus our attention on the FDI inward flow, and not on the inward stock, because the stock measure is unsatisfactory. In fact, FDI stock represents the direct investment position on a historical-cost basis, namely the investment amount already in the host country as opposed to the flow of capital into the host country at a considered year. As already highlighted by Cantwell and Bellack (1998), the use of the book value (which is the historical cost) does not take into account the distribution of the stock age. As a result, international comparison of FDI stocks is almost impossible.

[1] $CH_{4it} = \alpha + \beta_1\, GDPsctr_{it} + \beta_2\, GDPsctr^2_{it} + \beta_3\, FDIsctr_{it} + \beta_4\, FDIsctr^2_{it} + \beta_5\, SCTRrel_{it} + \beta_6\, MKTopn_{it} + \beta_7\, EDU + \beta_8\, CATTLE_{it} + \beta_9\, PROTarea_{it} + \beta_{10}\, CRpr_{it} + \varepsilon_{it}$

[2] $CO_2sctr_{it} = \alpha + \beta_1\, GDPsctr_{it} + \beta_2\, GDPsctr^2_{it} + \beta_3\, FDIsctr_{it} + \beta_4\, FDIsctr^2_{it} + \beta_5\, SCTRrel_{it} + \beta_6\, MKTopn_{it} + \beta_7\, EDU + \beta_8\, PROTarea_{it} + \beta_9\, CRpr_{it} + \varepsilon_{it}$

where: ***i*** represents the 30 cross-sectional units we have already said; ***t*** represents the time units already mentioned (1990-2005 for the analysis of model [1] and 1981-2005 for the analysis of model [2]); $\boldsymbol{\varepsilon}$ is the error term. We do not explain the meaning of the other considered variables since this is already done in table 3.1. The description of those variables representing the technique, scale and cumulative effects induced by GDP and FDI in our two equation models is already treated in section two where the materials and methods of our analyses are described[51]. Another few words need to be said in relation to the composition effect which we capture through the relevance of the sector (namely, variable no. 6 in table 3.1). We also tried to identify it through the use of a capital-labour ratio (with capital associated in turn to GFCF and GCF)[52] which we decided to drop because of the insignificant result achieved in the various estimation attempts.

A final explanation to justify the choice of introducing cross-products in our estimation relies on the fact that sometimes we need a test with power to detect ignored nonlinearities in model estimations and, especially, in those estimated by OLS or 2SLS. To do this, a useful approach consists in adding nonlinear

[51] Cole and Elliot (2003) observe how in the real world the GDP scale effect is likely to be contemporaneous while the GDP technique effect the result of some past dynamic. As they suggest, diversifying the variables in question by employing lagged terms could help to capture this aspect. Hence, we decided to lag both the variables representing the induced-GDP and the induced-FDI technique effects. As our evidence will show, the above consideration appears to be true for model [1]. It does not appear completely valid in model [2], where the best fit of the model estimation is achieved without lagging GDP but doing it for the FDI variable.

[52] The Gross Capital Formation (GCF) consists of: 1. Gross Fixed Capital Formation (GFCF), as below defined; 2. changes in inventories and acquisition in produced assets (like building roads, machinery, stock of commodities, etc.) less disposals of valuables for a unit or sector (http://stats.oecd.org/glossary).

functions, such as squares and cross-product (a vector obtained by the product of two other vectors) to the original function (Wooldridge, 2002)[53].

3.3.2. Results of the analysis.

To comment on our analysis results, which have been achieved by using the tool Stata/IC 12.1 for Windows, we begin by reporting the table below (tab. 3.2), where summary statistics of the variables considered in both our models appear. Afterwards, we will proceed with two different subsections where the results achieved for each of the two models above will be presented and discussed.

Tab. 3.2 – Summary statistics of the variables considered in models [1] and [2].

Variable	Obs	Mean	Std. Dev.	Min	Max
		model [1]			
Id	480	-	-	1	30
Year	480	-	-	1990	2005
EDU	480	2.168737	.2361877	1.373716	2.505526
PROTarea	480	-6.205169	1.807776	-9.219663	-1.6507
CATTLE	454	9.595933	1.232904	6.441844	11.71158
CH_4 **(dependent var.)**	448	-6.734959	.7001559	-8.583849	-4.896647
MKTopn	447	-2.067351	2.846427	-15.51018	1.11255
SCTRrel	443	-3.482158	.7153801	-5.598056	.3206728
$GDPsctr^2$	418	313.3441	110.9189	202.6947	816.761
GDPsctr	417	17.5572	2.612474	14.23709	28.40579
CRpr	375	-312.5475	174.3007	-919.3273	432.9947
$FDIsctr^2$	231	515.6398	80.58488	311.1336	777.9856
FDIsctr	230	-11.89744	19.36066	-27.89239	27.45324
		model [2]			
Id	750	-	-	1	30
Year	750	-	-	1981	2005
EDU	750	2.12257	.2730594	1.029619	2.505526
CO_2sctr **(dependent var.)**	744	-15.55893	.8372048	-18.57597	-12.6687
MKTopn	662	-2.459594	3.221396	-15.70503	3.740827
SCTRrel	650	-3.354633	.7404608	-5.598056	.3206728
GDPsctr	600	17.83365	2.826254	14.23709	31.6578
$GDPsctr^2$	599	326.0136	122.0182	202.6947	1002.216
CRpr	514	-321.9877	174.7688	-920.6189	432.9947
PROTarea	480	-6.205169	1.807776	-9.219663	-1.6507
$FDIsctr^2$	331	517.8182	80.28949	311.1336	777.9856
FDIsctr	330	-11.43911	19.69514	-27.89239	27.45324

[53] The implementation of such an approach is easy when all explanatory variables are exogenous. F and LM statistics for exclusion restrictions are easily achieved. Complications arise, instead, for models with endogenous explanatory variables, because we need to choose instruments for the additional non-linear functions of the endogenous variable. However, we must consider that "transforming into squares and cross product all exogenous variables can considerably consume degrees of freedom" (Wooldridge, 2002: 124).

3.3.2.1. Estimation results for model [1] built on CH_4 as dependent variable.

Before presenting the estimation procedures and outcomes, we report on the results of the tests used to check our model [1] specification for heteroskedasticity, autocorrelation and stationarity. For the first type of test, we employed a LR test, which performs a likelihood-ratio test for the null hypothesis (panel homoskedasticity) that the parameter vector of a statistical model satisfies some smooth constraints (Greene, 2007)[54]. Our LR test generated a Chi2(18) = 292.72 with a p-value = 0.0000. This implies that we reject the null hypothesis of the test, which is associated to the inexistency of heteroskedasticity, and confirm that our model specification has heteroskedasticity problems.

To check for autocorrelation, we recurred to a test developed by Wooldridge (2002) for panel data models, whose null hypothesis H_0 is associated to the inexistency of first-order autocorrelation[55]. The achieved result shows a F value (1, 14) = 94.632 and a p-value = 0.0000. Hence, we reject the null hypothesis of the test and accept the alternative hypothesis H_1 saying that our model specification is affected by autocorrelation.

The last test was to check whether the variables considered in our model specification are stationary or not. To this purpose, we employed the Fisher test which, as developed by Maddala and Wu (1999), combines the p-values from N independent unit-root tests and – unlike other types of test – gives the possibility of dealing with unbalanced panel data. Based on the p-values of individual unit-root tests, this test assumes that all series are non-stationary under the null hypothesis against the alternative that at least one series in the panel is stationary. The table here below (tab. 3.3.) reports the results of the test. Non-stationarity can be observed in correspondence with those variables showing a p-value ≥ 0.05 which makes us accept the null hypothesis of the test (H_0) that panels contain unit-root and reject the alternative hypothesis (H_1) that panels are stationary. As can be

[54] The LR test provides an important alternative to Wald testing for models fitted by maximum likelihood. Wald testing requires the estimation of only one model (the unrestricted model) and, for this reason, it is computationally more attractive than likelihood-ratio testing. However, whenever feasible, most statisticians recur to the likelihood-ratio testing since the null-distribution of the LR test statistic is often "more closely" chi-square distributed than the Wald test statistic.

[55] This test implies the use of the Stata *xtserial* command which implements a test for serial correlation in panel-data discussed by Woolridge (2002) and Drukker (2003).

observed, the test was run up to three lags and finds evidence that, except for the market openness variable, all the others are non-stationary[56].

Tab. 3.3 – Fisher test for panel unit-root using an augmented Dickey-Fuller test.*

Variable	Lag -1	Lag -2	Lag -3
	chi2	*chi2*	*chi2*
	p-value	**p-value**	**p-value**
CH_4 **(dep. var.)**	*88.3410*	*50.7080*	*40.4565*
	0.0038	**0.6748**	**0.9415**
GDPsctr	*31.4958*	*34.4661*	*59.2644*
	0.9967	**0.9896**	**0.3574**
$GDPsctr^2$	*33.7427*	*44.0703*	*65.7669*
	0.9920	**0.8759**	**0.1746**
FDIsctr	*48.3106*	*20.0024*	*13.9586*
	0.1220	**0.9729**	**0.9977**
$FDIsctr^2$	*23.3882*	*5.4078*	*2.6288*
	0.8657	**1.0000**	**0.9999**
SCTRrel	*169.3467*	*38.3992*	*36.0523*
	0.0000	**0.9780**	**0.9895**
MKTopn	*187.0651*	*121.3394*	*104.2179*
	0.0000	**0.0000**	**0.0002**
EDU	*19.5396*	*22.6780*	*33.1199*
	1.0000	**1.0000**	**0.9981**
CATTLE	*101.6096*	*46.9906*	*59.99711*
	0.0006	**0.8896**	**0.4768**
PROTarea	*74.3303*	*177.9399*	*91.3229*
	0.1009	**0.0000**	**0.0057**
CRpr	*65.1987*	*203.7623*	*155.1569*
	0.1873	**0.0000**	**0.0000**

** chi2 in italics, p-value in bold.*

To present the estimation results achieved for model [1], we can initially refer to the following table (tab. 3.4), where Ordinary Least Squares (OLS), Fixed Effects (FE) and Random Effects (RE)[57] are generated while considering all the

[56] This test is run through the use of the Stata *xtfisher* command which implements unit-root tests for heterogeneous panels based on the mean of individual unit-root statistics (Im et Al., 2003). It performs an Augmented Dickey-Fuller test and overtakes the problem characterizing other types of tests based on the assumption of no serial correlation which require serial correlation corrections before the unit-root test is performed.

[57] Pooled OLS models ignore the panel structure of the data and simply estimate while assuming that units or time effects are inexistent. They are characterized by the fact that all the typical OLS assumptions are not violated, the constant term is constant across all units and the effects of any given explanatory variable on the dependent variable is constant across observations. The Fixed effects model assumes that the individual specific effect is correlated with the independent variable. It controls for all time-invariant differences between the individuals and, therefore, its estimated coefficients cannot be biased because of omitted time-invariant characteristic. Fixed effects models are characterized by the inexistency of significant temporal effects and by the presence of significant differences among the unit groups. For this reason, they are characterized by constant slopes, although the intercept can vary across the cross-sectional unit groups. The random effects models assume that the individual specific effects are uncorrelated with the

variables in first-differences with the aim of overtaking the non-stationarity problem we have observed, controlling for serial correlation and avoiding spurious results[58]. The analysis result from the use of these models is corrected for heteroskedasticity and autocorrelation through the implementation of estimation strategies which produce robust standard error estimates for panel models[59].

Tab. 3.4 – Panel data estimation results for model [1].

CH_4 dep. var.	OLS	FE	RE
GDPsctr	-.0055*** (.0017391)	-.0033** (.0011589)	-.0034*** (.001096)
GDPsctr^2	.0004 (.0007873)	-.0005 (.0004367)	-.0005 (.0004471)
FDIsctr	.0199 (.0166297)	.0427* (.0218498)	.0345* (.0187577)
FDIsctr^2	.0004 (.000338)	.0009* (.0004568)	.0007* (.0003901)
SCTRrel	-.0178 (.0352826)	.0147 (.0237678)	.0131 (.0245004)
MKTopn	.0219 (.0312177)	-.0143 (.0159551)	-.0129 (.0168643)
EDU	.0840 (.115664)	.0040 (.0645614)	.0066 (.0706832)
CATTLE	.3716*** (.086067)	.3376*** (.0855671)	.3441*** (.0793544)
PROTarea	.0565 (.0347658)	.0167 (..0151317)	.0209 (.0156976)
CRpr	-.0001** (.0000164)	-.0001*** (.0000114)	-.0001*** (9.39e-06)
Constant	-.0113 (.0077274)	-.0069** (.002644)	-.0105* (0.0063446)
N. obs.	**87**	**87**	**87**
N. groups	**18**	**18**	**18**
R-squared	**0.2638**	**n.a. with robust estimates**	**Rho = .6135**
Adj. R-squared	**n.a. with robust estimates**		

Robust standard errors in parenthesis; P-value: * ≤ 1%, ** ≤ 5%; * ≤ 10%**

independent variables which allows for time-invariant variables to play a role as explanatory variables. So, the variation across entities is assumed to be random and this helps to generalize the inferences beyond the sample used in the model (Greene, 2007).

58 The decision to adopt a dynamic specification of our model and use first-differences is the result of the Engle-Granger test for cointegration we ran on the OLS model while considering our variables in levels (Engle & Granger, 1987). The test shows a p-value equal to 0.074 for the lagged value of the residuals $\hat{e}$. This makes us accept the null hypothesis of no-cointegration and means that the residuals of the regression are non-stationary and its variables are not cointegrated.

59 With specific regard to OLS and FE models, heteroskedasticity and autocorrelation are corrected through the use of robust standard errors generated by the *xtscc* Stata program. It reports Driscoll-Kraay standard errors which account for within-group correlation, heteroskedasticity and cross-sectional correlation. It produces heteroskedasticity and autocorrelation consistent standard errors that are robust to general forms of spatial (cross-sectional) and temporal dependence (Hoechle, 2007: 282). In addition, the *xtscc* program is capable of handling missing values, which makes it suitable for use with balanced and unbalanced panels, its standard errors are robust to forms.

Table 3.5 reports the results of the Brush-Pagan test (or LM test) for the choice between OLS versus RE/FE. We observe a chi2 equal to 52.36 with a p-value = 0.0000, which makes us drop the OLS and focus on choosing between RE and FE.

Tab. 3.5 – The Brush-Pagan (LM) test results.

	Var	**sd = sqrt(Var)**
CH_4	.0008774	.0296209
E	.0002557	.01599
U	.0004058	.0201453
Test: Var(u) = 0	**chibar2(1)** = 52.36	**Prob > chibar2** = 0.0000

Hence, for the choice between FE and RE, we run the Hausman test (tab. 3.6). Although generating a chi2 equal to 1.69 and p-value of 0.9982, the test fails since the matrix of variance is not positive definite. For this reason, we cannot take its result into consideration for the purpose of formulating our decision.

Tab. 3.6 – The Hausman test results.

	Coefficients		**(b-B)**	**Sqrt(diag(V_b – V_B))**
	(b) **Fe**	**(B)** **.**	**Difference**	**S.E.**
GDPsctr	-.0032621	-.0033722	.0001101	.
$GDPsctr^2$	-.0005195	-.0004573	-.0000623	.0001165
FDIsctr	.0427368	.0345065	.0082303	.002175
$FDIsctr^2$	.000903	.0007337	.0001693	.0000476
SCTRrel	.0147121	.0130995	.0016127	.
MKTopn	-.0142928	-.0129196	-.0013733	.0044435
EDU	.0040437	.0065644	-.0025207	.
CATTLE	.3375618	.3441082	-.0065465	.
PROTarea	.0166826	.020924	-.0042414	.
CRpr	-.0000875	.-.0000742	-.0000133	.

b = consistent under H0 and Ha; obtained from xtreg; B = inconsistent under Ha, efficient under H0; obtained from xtreg

Test: H0: difference in coefficients not systematic

Chi2(10) = (b-B)’[(V-b-V_B)^(-1)](b-B) = **1.69** **Prob>chi2 = 0.9982**

(V_b-V_B is not positive definite)

As a consequence, we go further and run a forced version of the Hausman test (tab. 3.7) by using a specific Stata option[60]. We get a chi2 equal to 14.21 and

[60] Sometimes, in finite samples, the Hausman test stat can result < 0 and fails to meet its asymptotic assumption because different estimates of the error variance are being used in V_b and V_B. Stata software provides us with the possibility of forcing the same variance to be used in both by employing the “sigmamore” option, which bases both (co)variance matrices on disturbance variance estimates from efficient estimators (Stata help).

a p-value of 0.1152. This result, however, is not useful to our choice purpose since it is accompanied by an alert on possible problems in computing the test.

Tab. 3.7 – The forced Hausman test results.

	Coefficients		**(b-B) Difference**	**Sqrt(diag(V_b – V_B)) S.E.**
	(b) Fe	**(B) .**		
GDPsctr	-.0032621	-.0033722	.0001101	.0003466
$GDPsctr^2$	-.0005195	-.0004573	-.0000623	.0001755
FDIsctr	.0427368	.0345065	.0082303	.0044835
$FDIsctr^2$	.000903	.0007337	.0001693	.0000949
SCTRrel	.0147121	.0130995	.0016127	.0056182
MKTopn	-.0142928	-.0129196	-.0013733	.0066446
EDU	.0040437	.0065644	-.0025207	.0174607
CATTLE	.3375618	.3441082	-.0065465	.0175987
PROTarea	.0166826	.020924	-.0042414	.0050153
CRpr	-.0000875	.-.0000742	-.0000133	7.56e-06

b = consistent under H0 and Ha; obtained from xtreg; B = inconsistent under Ha, efficient under H0; obtained from xtreg

Test: H0: difference in coefficients not systematic

Chi2(10) = (b-B)'[(V-b-V_B)^(-1)](b-B) = **14.21** **Prob>chi2** = **0.1152**

As a further consequence, according to what is suggested in the technical literature by Schaffer and Stillman (2010; 2006), we implement a recently developed robust test[61] through the use of an artificial regression approach described by Arellano (1993) and Wooldridge (2002)[62]. The result shows a chi2(10) equal to 117.452 and a p-value of 0.0000. Hence, we reject the null hypothesis associated to the consistency of the RE model and accept the validity of the FE model whose result will be the subject of our discussion[63].

[61] A test of FE versus RE can also be seen as a test of overidentifying restrictions. The fixed effects estimator uses the orthogonality conditions that the regressors are uncorrelated with the idiosyncratic error *e_it*. The random effects estimator uses the additional orthogonality conditions that the regressors are uncorrelated with the group-specific error *u_i* (the "random effect"). These additional orthogonality conditions are overidentifying restrictions (Stata help).

[62] In the artificial regression, a random effects equation is re-estimated augmented with additional variables consisting of the original regressors transformed into a deviations-from-mean form. The test statistic, which is a Wald test of the significance of these additional regressors, can also be seen as a test of overidentifying restrictions. It is asymptotically equivalent to the usual Hausman FE versus RE test and is implemented in Stata through the use of the *xtoverid* command. In contrast to the Hausman test, however, this extends straightforwardly to heteroskedastic-robust and cluster-robust versions and always generates a non-negative test statistic (Schaffer & Stillman, 2010; 2006).

[63] The variables in this model estimation are jointly significant, since the F-test shows a F(10, 218) = 223.18 and a p-value = 0.0000. In addition to this automatically generated test, we also run a F-test to check for the joint significance of the two variable associated to GDP and the other two variables associated to FDI. The earlier test generates F(2, 17) = 6.59 and a p-value = 0.0076. The latter shows F(2, 17) = 7.89 and a p-value = 0.0038. As a result, we reject the null hypothesis of the test that the estimated coefficients of the considered variables are jointly significantly equal to 0. Hence, we can say that our model including these variables is correctly specified.

With regard to the two relationships between the considered measures of GDP and CH_4, we observe a statistically significant (p-value = 0.012) and negative relationship (-0.0033) when GDP is considered as it is[64]. If we consider what has already been said in the previous pages of section two, this result, which represents the elasticity associated to the induced-GDP technique effect, has the environmental-economic meaning that a 1% increase of GDP determines a decrease of about 0.003% of CH_4. When GDP is considered in its quadratic form the relationship with CH_4 becomes statistically insignificant. This does not allow us to argue in terms of scale and cumulative effects of GDP on the dependent variable and, as will be better remarked in the concluding subsection of this paragraph, does not enable us to comment on the validity of the EKC theory. What we can generally and only say is that an increase of the income level generates a very slight decrease in the environmental degradation level.

With regard to the relationship between CH_4 emission and the sectoral inflow of FDI, we observe a statistically significant (p-value = 0.067) and positive result (0.0427) when the FDI variable is considered as it is[65]. Another significant (p-value = 0.065) and positive relationship (0.0009) is achieved between CH_4 and the sectoral inflow of FDI when this is considered in its squared form. As already said in section two of this chapter, the elasticities of the induced-FDI technique and scale effects are respectively observed through β_3 (the estimated coefficient of the FDI variable taken in isolation) and $2\beta_4$. In more detail, the elasticities are +0.0427 for the technique effect and +0.0018 for the scale effect. By bringing to solution $\beta_3 + 2\beta_4\ FDIsctr$, namely by operating the algebraic sum $0.0427 + 0.0018\ FDIsctr$, and considering for *FDIsctr* the mean value of the FDI inflow observable in the table of the summary of statistics[66], it is possible to compute the

[64] As already described in table 3.1, this variable is considered with a one-year lag. The justification for this could be seen in the fact that the CH_4-GDP relationship turns out to be validly evident from a statistical point of view probably because of the time needed by changes in the GDP level to generate their effects - namely, their technique effects - on the considered pollutant.
[65] Again, as described in table 3.1, where the specification of the variables in the models is reported, this variable is also considered with one-year lag. As in the previous footnote, the justification for doing so could be seen in the fact that changes in the FDI level exert their statistically significant effects - that is their technique effects - on the considered pollutant one year after their implementation.
[66] For the clarity of the computation methodology, we remind that the sample mean value of the FDI variable is equal to -11.89744 as shown in table 3.2 where the summary of the statistics of the variables considered for our sectoral investigation is reported.

induced-FDI cumulative effect which is equal to about +0.0213. In the consideration of the environmental-economic meaning of these achieved results we would say that, with regard to the technique effect, a 1% increase of the sectoral FDI inflow generates a increase of about 0.0427% of CH_4. The result associated to the identification of the induced-FDI scale effect would make us say that a 1% increase of the sectoral inflow of FDI determines an increase of about 0.0018% of CH_4. The cumulative effect refers, in percentage terms, to the response of the dependent variable to changes of the FDI level. As just observed, if computed at the sample mean value of FDIsctr, it is equal to 0.0213 and its positive sign is due to the algebraic sum of the technique and scale effects which are both characterized by positive signs.

The relationship between CH_4 and the variable representing the relevance of the "agriculture and fishing sector" is not found statistically significant. For this reason, we cannot comment on the impact this variable - representing in our model the aspect associated to the composition effect - exerts on CH_4. We also find statistically insignificant the variables represented by the market openness, and the education levels characterizing the considered economies.

Another positive (0.3376) and highly significant (p-value = 0.001) outcome is associated to the relationship between the dependent variable and the number of cattle in the considered countries. The practical meaning of this identified relationship is that an increase of 1% of the number of cattle would generate an increase of CH_4 by about 0.34%.

Statistically insignificant is the outcome associated to the relationship between the quantity of protected area characterizing our considered countries and the dependent variable.

Finally, another strongly significant (p-value = 0.000) and negative relationship (0.0001) is found between the variable representing the cross-product and CH_4. Its practical explanation would suggest that an increase of 1% of the sectoral relevance (in terms of increase of the GDP per worker in the considered sector) decreases the impact of the total flow of FDI on the dependent variable by about 0.0001%.

3.3.2.2. Estimation results for model [2] built on CO_2 as dependent variable.

In this section we present the results achieved from the analysis of the equation [2] above reported, which considers the natural logarithm of per-capita CO_2 emissions in the “agriculture and fishing” sector as a dependent variable. As done in the previous pages, before presenting the estimation procedures and results, we report the outcome of a few tests run with the aim of checking our model specification for heteroskedasticity, autocorrelation and stationarity. The LR test, which performs a likelihood-ratio test for the null hypothesis of panel homoskedasticity (Greene, 2007), shows a chi2(20) = 349.22 with a p-value = 0.0000. This implies that we reject its null hypothesis associated to the inexistency of heteroskedasticity, and confirm the existence of heteroskedasticity problems.

Autocorrelation was checked through a specific test for panel data models (Wooldridge, 2002) whose null hypothesis H_0 assumes the inexistency of first-order autocorrelation[67]. The result shows a F value (1, 16) = 121.111 and a p-value = 0.0000. It induces us to reject the null hypothesis and accept the alternative hypothesis H_1 saying that our model specification is affected by autocorrelation.

Through the employment of the Fisher test, as developed by Maddala and Wu (1999), we then checked our model specification to verify if the variables considered in it are stationary. We have already noted that this test combines the p-values from N independent unit-root tests and – unlike other types of test – gives the possibility of dealing with unbalanced panel data. Based on the p-values of individual unit-root tests, the test assumes that all series are non-stationary under the null hypothesis against the alternative that at least one series in the panel is stationary. The test – up to three lags[68] – is again run for all the variables in our considered panel, and not only for the sectoral CO_2 emission (the dependent variable in this new model), because they refer to the period 1981-2005. The test in the previous section was referred, instead, to variables related to the period 1990-2005. Table 3.8 here below shows the results of the new test. As we can

[67] Here again, this test is based on the use of the Stata *xtserial* command which implements the Woolridge test for serial correlation in panel data (Drukker, 2003; Woolridge, 2002).
[68] As reported in footnote 56, we use the Stata *xtfisher* command.

observe, the majority of our variables are non-stationary since they show a p-value ≥ 0.05 which makes us accept the null hypothesis H_0, associated with the fact that they are characterized by unit-roots.

Tab. 3.8 – Fisher test for panel unit-root using an augmented Dickey-Fuller test*.

Variable	Lag -1	Lag -2	Lag -3
	chi2 / **p-value**	*chi2* / **p-value**	*chi2* / **p-value**
CO_2sctr **(dep. var.)**	*87.7182* / **0.0113**	*55.9233* / **0.6254**	*66.3847* / **0.2664**
GDPsctr	*40.2439* / **0.9634**	44.1879 / **0.9095**	*51.7711* / **0.7047**
GDPsctr^2	*46.8202* / **0.8532**	*42.7446* / **0.9333**	*54.4113* / **0.6095**
FDIsctr	*80.4139* / **0.0002**	*40.2672* / **0.2870**	*35.2848* / **0.4073**
FDIsctr^2	*24.1866* / **0.8376**	*4.4060* / **1.0000**	*6.2555* / **0.9950**
SCTRrel	*57.8478* / **0.4809**	*40.9166* / **0.9566**	*39.2747* / **0.9718**
MKTopn	*119.9346* / **0.0000**	*105.2773* / **0.0001**	*56.4148* / **0.5344**
EDU	*28.3284* / **0.9998**	*40.3724* / **0.9758**	*99.6644* / **0.0010**
PROTarea	*74.3303* / **0.1009**	*177.9399* / **0.0000**	*91.3229* / **0.0057**
CRpr	*102.5609* / **0.0003**	*95.0358* / **0.0005**	*169.0008* / **0.0000**

** chi2 in italics, p-value in bold.*

As a consequence, we again proceed to analyze our panel while considering the variables in first-differences to deal with the non-stationarity problem and control for serial correlation[69]. As already done in the previous sections, we estimate robust OLS, FE and RE models due to the existence of heteroskedasticity and autocorrelation problems in our panel. Their results are shown in the table below (tab. 3.9). An initial look at the estimates achieved shows, as could be expected, that this model does not produce any significant outcome in terms of the

[69] As in the previous estimation case, once again we decide to transform our variables in first-differences to adopt a dynamic specification of our model. This comes as a result of the Engle-Granger test for cointegration we ran on the OLS model while considering our variables in levels. The test generates a lagged value of the residuals $\hat{e}$ showing a p-value equal to 0.056 which makes us accept the null hypothesis of no-cointegration. This means that the residuals of the regression are non-stationary and its variables are not cointegrated.

sectoral CO_2-GDP relationship[70]. However, indications of the effect that the sectoral FDI inflow exerts on CO_2 - which is actually the main purpose of our investigation - are produced.

Tab. 3.9 – Panel data estimation results for model [2].

CO_2sctr dep. var.	**OLS**	**FE**	**RE**
GDPsctr	-.0032 (.0062017)	.0101* (.0050995)	-.0032 (.0054187)
$GDPsctr^2$	.0019 (.0016746)	.0014 (.0020731)	.0019 (.0017079)
FDIsctr	-.0848*** (.045561)	-.1318*** (.0292269)	-.0848*** (.026198)
$FDIsctr^2$	-.0018*** (.0008641)	-.0027*** (.000599)	-.0018*** (.000565)
SCTRrel	-.1358 (.1266087)	-.0675 (.1371938)	-.1358 (.1373609)
MKTopn	.0517 (.0679675)	.0162 (.0801983)	.0517 (.066728)
EDU	.1320 (.4898129)	.1819 (.344598)	.1320 (.3589489)
PROTarea	-.0462 (.1111729)	-.0961 (.1563837)	-.0462 (.114618)
CRpr	.0004*** (.000052)	.0004*** (.0000554)	.0004*** (.0000448)
Constant	-.0062 (.0130101)	-.0008 (.0104774)	-.0062 (.0120121)
N. obs.	**94**	**94**	**94**
N. groups	**20**	**20**	**20**
R-squared	**0.1614**	**n.a. with robust estimates**	**Rho = 0**
Adj. R-squared	**n.a. with robust estimates**		

Robust standard errors in parenthesis; P-value: * ≤ 1%, ** ≤ 5%; * ≤ 10%**

The Brush-Pagan (LM) test shows a chibar2 equal to 0.00 with a p-value equal to 1.0000 (tab. 3.10) which make us choose the OLS model over FE and RE[71].

[70] The reason for this expectation is due to the fact that, although here we are working on IEA estimates of CO_2 from fuel combustion in the “agriculture and fishing” sector, it must be highlighted that this pollutant is not really associated to the exercise of agricultural activities. In fact, according to estimates of the World Resources Institute (WRI) – which will be better presented in the concluding section – the quota of “other fuel combustion” associated to “agricultural energy use” is just 1.4% of the total CO_2 generated by anthropogenic activities (Herzog, 2009; Baumert et Al., 2005).

[71] The F-test for the joint significance of the variables in the OLS model is highly statistically significant with $F(8, 19) = 60.29$ and a p-value = 0.0000. In addition, the F-test is also run to check for the joint significance of the two considered FDI variables which shows a p-value = 0.0003. Therefore, we reject the null hypothesis of the test and can say that our model including these variables is correctly specified.

Tab. 3.10 – The Brush-Pagan (LM) test results.

	Var	**Sd = sqrt(Var)**
CO_2sct	.0076741	.0876018
E	.0073743	.0858737
U	0	0
Test: Var(u) = 0	**Chibar2(1)** = 0.00	**Prob** > **chi2** = 1.0000

We can observe how the two variables associated to GDP (namely, the sectoral GDP per worker and its squared version) do not generate any useful statistical evidence. As a result and in contrast to the estimation of the previous model, this time we are unable to make any comment on the relationship between CO_2 and GDP and on the induced-GDP technique, scale and cumulative effects on the dependent variable.

The two variables linked to the FDI flow (the one-year lag FDI and the FDI squared), instead, show evidence of statistical relevance. More specifically, we observe a statistical significant (p-value = 0.001) and negative relationship (-0.0848) when FDI is taken as it is[72]. Another significant (p-value = 0.000) and negative relationship (-0.0018) between CO_2 and the sectoral inflow of FDI is achieved when FDI is considered in its squared form. Referring back to what has already been said in section two and similarly to what we have done in the previous section, the elasticities of the induced-FDI technique and scale effects are respectively observed through β_3 (the estimated coefficient of the FDI variable taken in isolation) and $2\beta_4$ derived from the partial derivative of our considered equation with respect to FDI. In this specific case, the elasticities are -0.0848 for the technique effect and -0.0036 for the scale effect. The elasticity of the induced-FDI cumulative effect is represented, as a consequence, by the estimated betas in $\beta_3 + 2\beta_4\ FDIsct$, namely *-0.0848-0.0036(LnFDIsctr)*. By bringing to solution this algebraic relation while considering, as an example, for *FDIsctr* the mean value of the FDI inflow (as shown in the table of the summary of the statistics) the cumulative effect can be actually computed and results equal to -0.0436[73].

The practical explanation of the environmental-economic meaning of these results would make us say that, with regard to the technique effect, a 1% increase

[72] As described in table 3.1, this variable is again considered with a one-year lag to mean that it exerts its statistically significant effects - that is technique effects - on CO_2 with a lag of one year.
[73] As done in the analysis of model [1], we remind that the sample mean of the OECD countries' sectoral inflow of FDI is equal to -11.43911.

of the sectoral FDI inflow generates a decrease of about 0.0848% of CO_2. The result associated to the identification of the induced-FDI scale effect would make us say that a 1% increase of the sectoral inflow of FDI determines a decrease of the sectoral CO_2 emission by about 0.0036%. Finally, the cumulative effect, which is the actual response (always in percentage terms) of the dependent variable to changes of the FDI level, would indicate a decrease of - *0.0848 - 0.0036 FDIsctr* when the FDI level increases by 1%. As already said, it is equal to -0.0044 if computed while considering the mean value of FDI in our sample and its negative sign is the result of the algebraic sum between the technique and scale effects, which are both negative.

Our analysis does not find any evidence of statistical significance for the variable associated to the sectoral relevance (SCTRrel). Therefore, we are unable to comment on the composition effect. The variables representing the market openness (MKTopn), education (EDU) and protected areas (PROTarea) are also found to be statistically irrelevant.

The last noteworthy finding of our analysis is the statistically significant (p-value = 0.0000) and positive relationship (0.0004) between the cross-product accounting for the interactive effect of GDP and the total inflow of FDI on CO_2. This would suggest that an increase of 1% of the sectoral GDP generates an increased impact – although quantitatively insignificant – of about 0.0004% of the total inflow of FDI on CO_2.

3.3.3. Concluding remarks.

In this section we have mainly analysed the relationship between the inflow of FDI in the "agricultural and fishing sector" of OECD countries and the emission levels of two pollutants, namely CH_4 and CO_2 from fuel combustion in the sector. We have done this while referring to two different periods (1990-2005 for the earlier and 1981-2005 for the latter) to primarily assess whether FDI plays a role in the dynamics of the two considered pollutants or, in more general terms, to observe if FDI can be considered beneficial or detrimental to the environment.

To this purpose, we have constructed a panel dataset containing data for 30 countries, 16 years (for CH_4) and 25 years (for CO_2 from sectoral fuel combustion). The dataset is strongly unbalanced due to gaps in the statistical information on the source databases of the various international organizations we consulted. Our empirical investigation focused on two similar equation models – one for each considered pollutant (model [1] for CH_4 and model [2] for CO_2) – organized in such a way to take into account technique, scale and composition effects according to the mainstream literature. These two models were estimated through the use of the panel-data technique and their concluding discussions and policy considerations will be presented in the next two sub-sections.

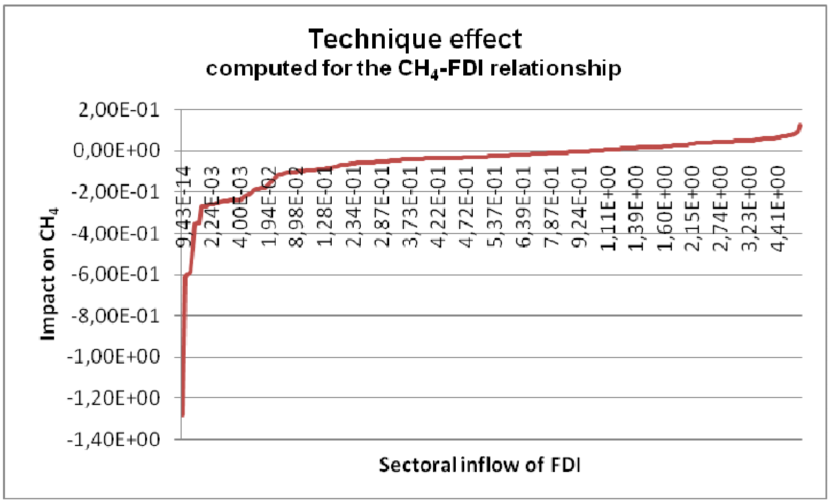
3.3.3.1. Discussion and conclusions of model [1].

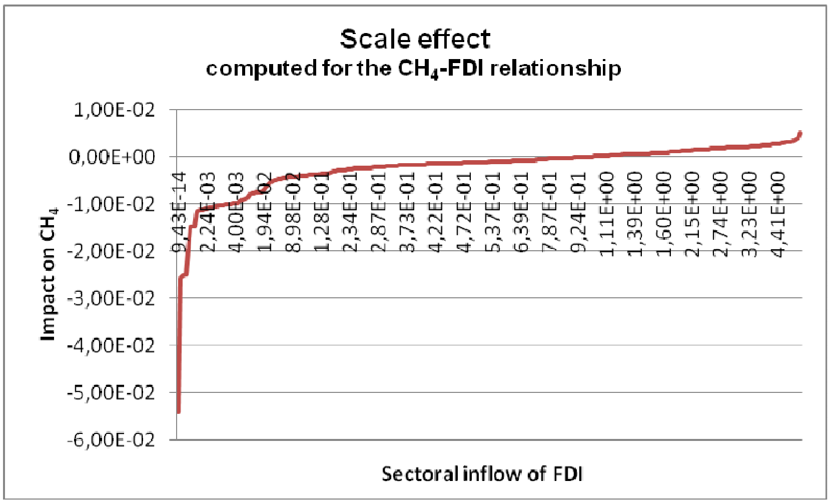
3.3.3.1.1. The induced-FDI technique, scale and cumulative effects.

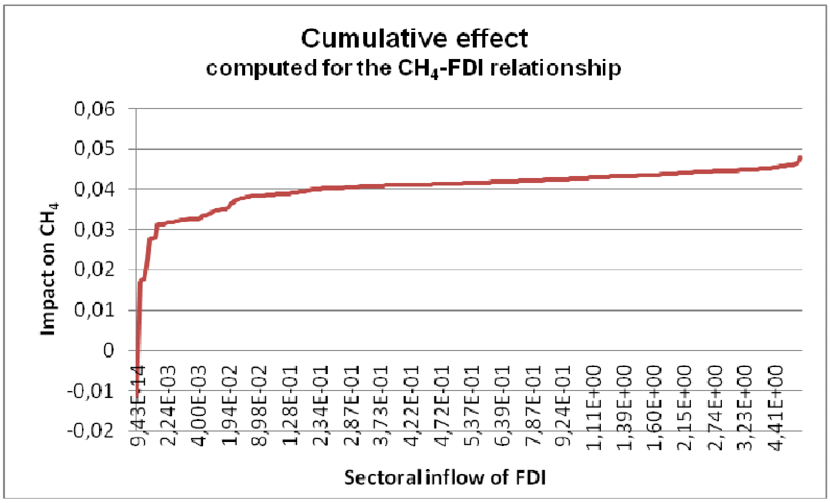
The observation of the results achieved with regard to the FDI-CH_4 relationship based on the separation of the technique effect (associated to the FDI variable taken in isolation) from the scale effect (associated to the FDI variable in its squared form and computed according to what is said in the methodological section) highlights a technique effect characterized by a positive relationship (the specific coefficient is equal to +0.0427) between the sectoral inflow of FDI and the considered pollutant. This result would prove that FDI inflowing in the considered sector generates an increase of CH_4 and, therefore, is detrimental to the environment of our considered receiving countries. At first glance, therefore, we have some difficulties in going along with that mainstream thinking - more extensively reported in the chapter reviewing the literature - which talks about a beneficial effect of FDI on the environment. It is explained through a technological effect implicitly associated to FDI which is capable of bringing higher production efficiency levels and minor polluting emissions as a generally expected result (e.g. Liang, 2006). In addition, when the measure of FDI is squared with the aim of taking into account the scale effects (whose coefficient is equal to +0.0018), the role of the FDI flow on CH_4 still appears to be detrimental to the environment because of its positive algebraic sign. Finally, as a result of the algebraic sum between the induced-FDI technique and scale effects, the cumulative or total effect (averagely equal to +0.0213) definitively shows a positive sign and confirms the detrimental role played by FDI on CH_4.

The dynamics of what has been referred so far can be better represented by resorting to some graphs (graph 3.4) where the effects of the sectoral FDI inflow on CH_4 (this intended in terms of Gg. of CO_2 equivalent) are plotted on the basis of the technique, scale and cumulative effect coefficients estimated in our empirical analysis.

Graph 3.4







It can now be more clearly observed how the relationship between CH_4 and FDI is initially characterized by an increasing trend due to the positive elasticity of the technique effect. Hence, CH_4 emission increases as a result of the increase of the sectoral inflow of FDI at a first stage. At a later stage, in correspondence to a turning point we identify at a level of FDI per-GDP equal to 4.99E-11,[74] the elasticity of the scale effect still remains positive but the relationship between CH_4 and FDI slightly changes its trend. In fact, the level of CH_4 still increases in response to further rises of FDI but at a slower pace. However, the overall impact of FDI on CH_4 basically remains detrimental to the environmental feature we are considering since its increase would generally result in an increase of the emission level of the considered pollutant. As already pointed out, this happens because of the positive sign characterizing the elasticity of the cumulative effect which is the result of the algebraic sum between the technique and scale effects both characterized by a positive sign.

The evidence we achieve agrees with those works which have found positive correlations in the FDI-environment relationship while working with different sets of pollutants (e.g. Bao et Al., 2011; Shahbaz et Al., 2011; He, 2008; 2006) and differs from other analyses, which conclude their considerations by recognizing the beneficial role of the FDI inflow on the environment. In this latter

[74] For a methodological indication, the turning point is obtained from computing the partial derivative with respect to FDI of our estimated function ($LnCH_4 = 0.0427\ LnFDI + 0.0009\ LnFDI^2$) and then making it equal to zero. The result is LnFDI = -(0.0427/0.0018) = -23.27 which converted into real numbers through exp(-23.27) gives 4.99E-11.

sense, for example, Kirkulak et Al. (2006) prove the existence of this virtuous circle in the FDI-environment relationship while working with different pollutants, that is those associated to the air quality of Chinese receiving territorial areas.

However, apart from this still unresolved double view existing in the literature and going beyond the observation of the algebraic signs characterizing the statistical evidence we have achieved, it must be stressed that our result is characterized by a very low number which could be seen as irrelevant from a quantitative point of view. This would more appropriately lead us to argue in terms of an almost neutral role of the sectoral inflow of FDI on CH_4. Further analysis of the investment patterns within the agricultural and fishing sector in the considered countries and over the considered period could help us to understand whether the above-mentioned quantitatively insignificant value characterizing the FDI-CH_4 positive relationship is the result of the fact that investment has moved away from more polluting practices in terms of CH_4 (e.g. the running of livestock activities) to approach others which are less polluting (e.g. the running of rural tourism activities). Unfortunately, to the best of our knowledge, there are no documents which can support us in this sense[75]. However, the fact that foreign investment inflowing in the analysed sector of the considered countries is characterized by certain levels of technological development could still be a possible explanation of our positive but quantitatively irrelevant result. In addition, one should also recognize that investment takes place in contexts which are characterized and conditioned by certain policy decision activities.

With regard to this, it must be considered how, particularly in the last three decades, the relationship between agriculture and the environment has become a very prominent issue in agricultural policies of OECD countries. In fact, all OECD countries have imposed and still impose regulatory requirements (which can vary from outright prohibition to standards and resource-use limits) at state, regional and provincial or local level to deal with the negative environmental

[75] Neither the analysis of the World Investment Reports published by the United Nations Conference on Trade and Development (UNCTAD) nor the search for other works in the specific literature helps us in bridging this lack of information. For this reason, the carrying out of specific research should be recommended to cover this information gap. Of course, this is not done in the context of this study, since it goes well beyond our analysis purpose.

effects of agricultural practices (OECD, 2003). As a result, a variegated set of agro-environmental measures have been produced and implemented through direct regulations, economic instruments, and the carrying out of education and persuasion activities (OECD, 2008[a]). It is well known that, with the aim of reducing the negative environmental impact of agriculture, many countries have taken direct action. For example, European countries and The United States widely recurred to the use of incentive payments during the 1990's. More specifically, this kind of instrument has been used to support the use of less intensive farming practices, land retirement payments tailored to specific environmental objectives, and transitional payments to assist farmers in implementing structural changes, which could result beneficial to the environment[76]. Other countries such as Australia, Canada and New Zealand have instead widely recurred to the use of community-based approaches (i.e. supporting collective action through the organization of land-care groups or conservation clubs), which rely on the farmers' self-interest in environmental conservation and make use of local expertise to solve environmental problems.

In the consideration of the very slightly detrimental - and, more appropriately, almost neutral - role of FDI on CH_4 we have observed, a possible policy implication could be seen in the enforcement of investment (and free trade), As we have already mentioned, in fact, FDI is generally recognized as a transfer of modern and advanced technology and this can be particularly true within the regulatory framework characterizing the OECD countries.

3.3.3.1.2. The induced-GDP technique, scale and cumulative effects.

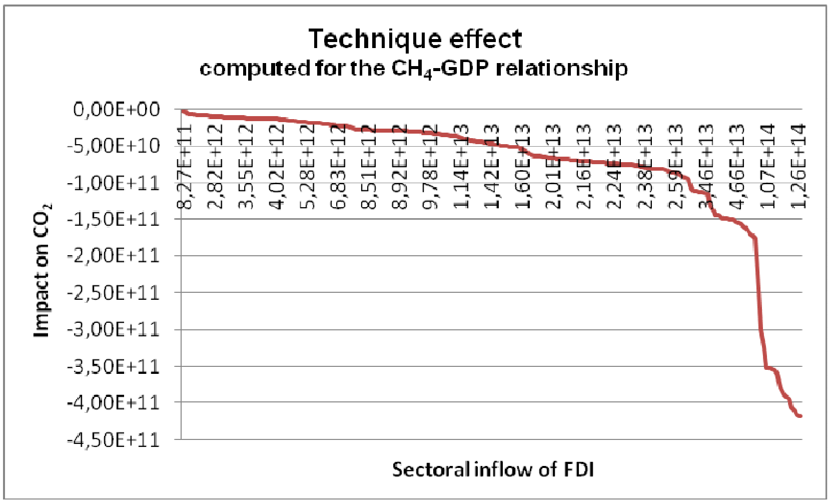
With regard to the relationship between GDP and CH_4, that is our considered pollutant agent in model [1], only the GDP variable taken in isolation

[76] With specific regard to the European Union (EU 15), for example, farming has been and still is supported under the Common Agricultural Policy (CAP) together with additional national expenditure within the CAP framework, although a slight decrease from 39% to 34% can be observed between the 1980's and 2002-2004 (OECD average was about 30%). In the mid-1980's, about 98% of the support given to European farmers was related to input and output performance. This level fell to about 70% up to 2004. However, it must be highlighted how support to farmers also considered the agri-environmental measures (AEMs) in terms of rewards to be given when activities considered beneficial for the environment are undertaken (OECD, 2008[a]).

was found statistically relevant. In contrast, when GDP was considered in squared terms to take into account the scale effect in our model, no evidence of statistical significance could be observed. As a result, we can only comment on the induced-GDP technique effect on the dependent variable and cannot do the same for the scale and cumulative effects. This will not allow us to make any kind of consideration with regard to the EKC and the computation of a turning point characterizing the relationship now subject of our attention.

As already observed, the estimated coefficient of the induced-GDP technique effect on CH_4 is equal to -0.0033 and shows a decrease of the CH_4 level in response to the increase of the GDP level. The graph below (graph. 3.5), where the induced-GDP technique effect on CH_4 (intended in terms of Gg. of CO_2 equivalent) is plotted, helps us to build a clearer view on the associated dynamic.

Graph 3.5



This evidence of a decreasing trend between CH_4 and GDP induces us to generally argue in terms of a beneficial role played by GDP on our considered pollutant. Once again and according to what the literature generally refers, this could be explained by the fact that an increase in GDP implicitly brings with it the effect associated to the development and diffusion of technological innovation from which minor levels of environmental impact are generally expected. As already anticipated, we cannot develop any discussion in relation to the EKC issue since we have not achieved any useful evidence when computing the scale effect -

and the cumulative effect as a result - considered in our model. Nevertheless, our analysis gives us indication, although in a very broad sense, that increases in the level of GDP generate pollution abatement.

It is perhaps the case to highlight, however, that apart from the observation of the algebraic sign of our empirical result, a better look at the coefficient of the technique effect we have achieved would make us observe a very low number which appears almost insignificant from a quantitative point of view. As a consequence, we feel to more properly argue in terms of the neutral role that GDP plays on CH_4.

The policy suggestion deriving from our result would make us broadly consider – according to the typical approach of the EKC policy implications – that a push towards the generation of major levels of GDP - that is becoming richer - might represent a solution to environmental problems. In other terms, although conscious of the limit of our evidence in terms of EKC framework of analysis, the inverse relationship found between CH_4 and GDP would make us very broadly say that population or country richness per sé can be considered as a driver for pollution abatement or, at least, as a factor to guarantee a nearly-zero pollution level.

3.3.3.1.3. The impact of FDI on CH_4 through GDP.

Having referred insofar to the effect the sectoral FDI and the sectoral GDP in isolation exert on the level of our considered pollutant, it is useful to assess how CH_4 is affected by FDI through GDP. It is realistic to assume, in fact, that GDP is influenced by FDI. We do so in the attempt to build a more complete picture of the empirical evidence whose production this work is devoted to.

To this purpose, while considering our data in first-differences due to all the reasons already referred to in the previous sections, we run OLS, FE and RE estimations of the following functional relationship which is considered - as previously done - in log-log terms to get the elasticities of the investigated relationship:

$$GDPsctr_{it} = \alpha + \beta_1 FDIsctr_{it} + \beta_2 FDIsctr^2_{it} + \beta_3 SCTRrel_{it} + \beta_4 MKTopn_{it} + \beta_5 PROTarea_{it} + \beta_6 CRpr_{it} + \varepsilon_{it}$$

where: *i* represents the 30 cross-sectional units we already know; *t* is the time span from 1981 and 2005; *GDPsctr* is the sectoral GDP normalized on the basis of the amount of workers in the "agriculture and fishing" sector; *FDIsctr* and *FDIsctr*^{2} are the sectoral inflow of FDI per-capita considered in its linear and quadratic terms respectively; *SCTRrel* is the variable associated to the sectoral relevance; *MKTopn* is the variable representing the market openness; *PROTarea* is the surface of protected area; *CRpr* is the cross-product we have already talked about in the previous sections; ε is the error term[77].

The result of the above-mentioned estimations are presented in the table below (tab. 3.11). They are produced on the basis of robust standard errors by following the same estimation strategies already described in the previous section.

Tab. 3.11 – Panel data estimation results.

GDP dep. var.	**OLS**	**FE**	**RE**
FDIsctr	-.1830*** (.060772)	-01184** (.0685309)	-.1830*** (.0638518)
FDIsctr^2	-.0068*** (.002192)	-.0044** (.0024634)	-.0068*** (.0023247)
SCTRrel	.9285*** (.1248675)	.9247*** (.0866231)	.09285*** (.0983888)
MKTopn	-.9251*** (.0442102)	-.9373*** (.0322506)	-.9251*** (.0437837)
PROTarea	-.2818*** (.0995262)	-.1572 (.091909)	-.2818*** (.0996816)
CRpr	.0002 (.0001165)	.0008 (.0000544)	0.0002 (.0000727)
Constant	.0981*** (.0151892)	.0965*** (.0044085)	.0981*** (.0151633)
N. obs.	**100**	**100**	**100**
N. groups	**20**	**20**	**20**
R-squared	**0.9412**	**n.a. with robust estimates**	**Rho = 0**
Adj. R-squared	**n.a. with robust estimates**		

Robust standard errors in parenthesis; P-value: * ≤ 1%, ** ≤ 5%; * ≤ 10%**

[77] This functional relationship is basically similar to that used for the estimation of model [1] and has been estimated by using the same estimation strategy previously described. Only the FDI and the FDI^2 variables had to be changed from per-GDP to per-capita terms to achieve statistically significant results. The other variables we consider here are exactly the same as those already described in table 3.1 where the specification of the variables was reported.

The Brush-Pagan test, computed for the choice between OLS and FE/RE models, generates a chibar2 = 0.00 and a p-value of 1.0000 which make us choose the OLS over the FE/RE.

Tab. 3.12 – The Brush-Pagan (LM) test results.

	Var	**Sd = sqrt(Var)**
GDP	.2784767	.5277089
E	.0161665	.1271476
U	0	0
Test: Var(u) = 0	**Chibar2(1)** = 0.00	**Prob > chi2** = 1.0000

Since our aim is now to identify the impact of FDI on CH_4 through GDP, we limit our consideration to the GDP-FDI relationships and will not comment on any evidence we have achieved. The answer to the question now subject of our attention, in fact, can be achieved by recalling the estimation result we achieved for model [1]

$$CH_4 = - 0.0033\ GDP + 0.0427\ FDI + 0.0009\ FDI^2 + ...$$

from which we take the partial derivatives of $\partial CH_4 / \partial FDI$ and $\partial CH_4 / \partial GDP$ and the result from the estimation we have just run, namely

$$GDP = - 0.1830\ FDI - 0.0068\ FDI^2 + ...$$

from which we take the partial derivative of $\partial GDP / \partial FDI$. By computing $[(\partial CH_4 / \partial FDI) + (\partial CH_4 / \partial GDP)] \times (\partial GDP / \partial FDI)$, with FDI and GDP considered at their sample mean values (FDI = -11.8974, and, although not needed in this specific computation case, GDP = 17.5572 we take from the table of the descriptive of the statistics), we get a result equal to -0.0003. This outcome would represent the quantitative measure (in average terms) of the actual impact generated by the sectoral inflow of FDI on CH_4 (in terms of Gg. of CO_2 equivalent) as observed through GDP. As can be noted, its negative sign confirms what was said in the previous section where the induced-GDP effects on CH_4 were examined and corrects the sign of the trend we previously observed when analyzing the induced-FDI effects on CH_4.

What is relevant to highlight, however, is the very minimal quantitative aspect of the figure just computed which would confirm - independently from the consideration of the algebraic sign - the neutral role FDI plays on our considered pollutant.

3.3.3.1.4. The composition effect.

With regard to the composition effect, considered in our modelling in terms of relevance of the "agriculture and fishing" sector in the whole economy, the various attempts of estimating model [1] did not generate any statistically useful evidence. As a result, we forego to comment on this specific aspect.

3.3.3.1.5. Other evidence.

We have already pointed out that the variables represented by the market openness, education and protected area did not result statistically significant. For this reason, we do not comment on them.

A meaningful relationship found in this work, and deriving from the use of a specific variable considered only in model [1], is that related to the positive relationship between CH_4 and the quantity of cattle existing in our considered countries. This result is in accordance with recent work investigating the existence of similar relationships (i.e. Jorgenson & Birkholz, 2010) and agrees with our expectations deriving from what has been learned from various reports produced by international organizations. These stress the positive correlation between cattle and CH_4, as we have already mentioned in the introductory section (EPA, 2011; World Bank, 2009; IPCC, 2007). This finding highlights how in the agriculture sector, and especially for cattle and manure management, a policy aiming at controlling the feeding process of cattle would be desirable, on the consideration that – as reported in the literature for this point – technological innovation for the production of both cereals and cattle (which are basically related to feeding modification techniques) are already well implemented in the experience of countries such as New Zealand.

The last noteworthy result of our empirical work was found in the negative relationship between CH_4 emissions and the cross-product we used. If we consider that it was thought and constructed with the idea of assessing the impact the total inflow of FDI exerts on the dependent variable through changes in the sectoral GDP level, our result might be seen as having a twofold meaning. In broad terms, it could first be intended as a clear confirmation of what we have said in the previous section when examining the effect of FDI on CH_4 through GDP. Second, it might be intended as a general indication of how the polluting agent we consider changes in response to changes of the level of relevance of our investigated sector. A policy indication associated to this kind of evidence cannot take any other form than suggesting a push towards increases of the relevance of our considered sector due to it being compatible with the environmental feature we have analyzed.

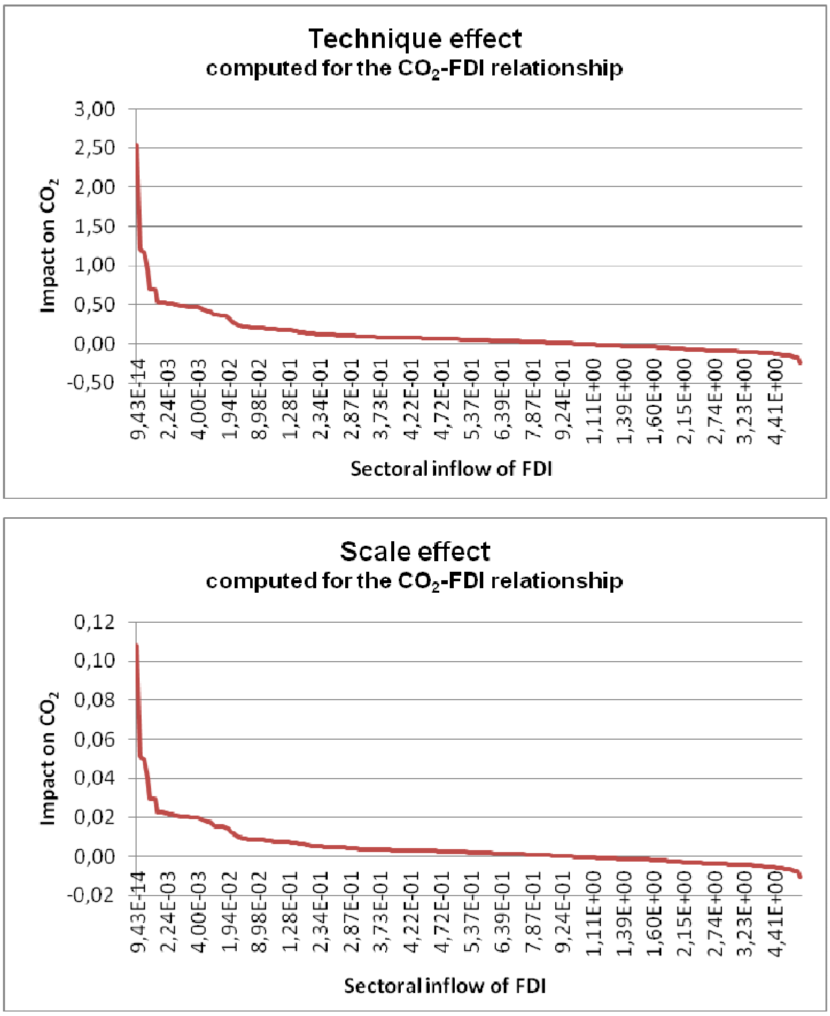
3.3.3.2. Discussion and conclusions of model [2].

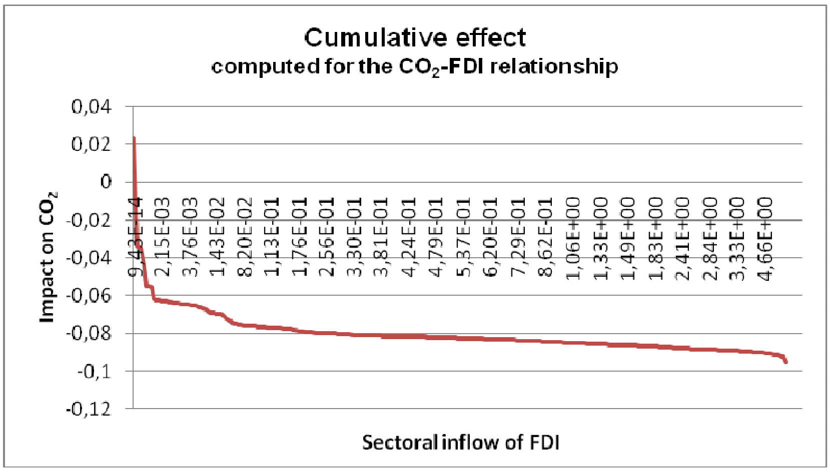
3.3.3.2.1. The induced-FDI technique, scale and cumulative effects.

The estimation of model [2] gives us evidence of the existence of a statistically significant relationship between the dependent variable (CO_2 emissions form sectoral fuel combustion) and the sectoral inflow of FDI considered in its linear and quadratic terms. The contemporary observation of this result and that achieved for the CO_2-GDP relationship (which does not show any evidence of statistical significance as will be reported in more details in the next section) would induce us to think that the generation of CO_2 emissions in the "agriculture and fishing" sector is more linked to the activities run with the concourse of foreign investment - probably due to their production modes - rather than those exerted in the sector considered as a whole. It is not a case, in fact, that the contribution of the agricultural sector to the generation of the considered type of polluting emission is very small, as will be seen later. This may be the reason why our model statistically explains the relationships subject of our interest with respect to FDI and not to GDP.

Having said this and entering the details of our considerations on the technique, scale and cumulative effects of the CO_2-FDI relationship, our analysis makes us observe a technique effect equal to -0.0848, showing a beneficial role of the considered investment flow for the environment since it highlights a decrease of CO_2 in response to an increase of FDI. The same could be observed when considering the scale effect, that is when considering the FDI variable in its quadratic form, for which a coefficient equal to -0.0036 is achieved. This beneficial role of the sectoral inflow of FDI on our dependent variable is confirmed by the cumulative effect characterizing our investigated relationship which is equal -0.0044 (computed as an average) as a result of the algebraic sum between the technique and the scale effects. The graph here below (graph 3.6) gives a better idea of the trends associated to the above-mentioned effects.

Graph 3.6





As we can more clearly observe, at a first stage the CO_2-FDI relationship is characterized by a decreasing trend due to the negative elasticity associated to the technique effect. As a result of this, CO_2 decreases as FDI increases. At a later stage, in correspondence with a turning point we compute at the level FDI per-GDP equal to 5.92E-11[78], the elasticity of the scale effect is still negative but flattens the trend with the result that CO_2 still decreases as FDI increase but at a slower rate. The overall impact of FDI on CO_2, highlighted by the cumulative effect, keeps showing the beneficial role of FDI on the environmental feature under consideration since an increase of the investment level cumulatively generates a decrease of the emission level of our considered pollutant.

Our result agrees with those studies which have found evidence of the beneficial role of FDI on CO_2 through the observation of a negative relationship between them, while specifically focusing their attention of analysis on the agricultural sector (e.g. Yanchun, 2010). However, a different view unavoidably exists and is expressed in those analyses where opposite evidence has been produced. Jorgenson (2007), for example, finds a positive relationship between the inflow of FDI in the primary sector and CO_2 emissions, although his case

[78] As for a methodological note, the turning point is now computed by considering the partial derivative with respect to FDI of our estimated function ($LnCO_2$ = -0.0848 LnFDI - 0.0018 $LnFDI^2$) and then making it equal to zero. The result is LnFDI = -(0.0848/0.0036) = -23.55 which converted into real numbers through exp(-23.5) gives 5.92E-11.

study was a focus on less developed countries and the amount of CO_2 emissions level was considered in different terms from those we have used[79].

Once again, apart from the debate still open in literature and going beyond the observation of the algebraic signs of the coefficients we have achieved from our analysis, the consideration of their quantitative aspect should induce us to speak in terms of an almost neutral role of FDI on the considered pollutant.

In the consideration of the result we have achieved, the policy suggestion could convincingly go along with the indication of enforcing the sectoral inflow of FDI (and trade liberalization with it). It is very likely, in fact, that FDI is characterized by levels of technological innovation which make possible the beneficial - and almost neutral - role it exerts on the CO_2 emission level from the sectoral fuel combustion.

3.3.3.2.2. The induced-GDP technique, scale and cumulative effects.

Model [2] failed to give us significant results with regard to the two considered relationships (linear and quadratic) between the CO_2 emissions from the sectoral fuel combustion and the sectoral GDP. Therefore, we are unable to comment either on the technique effect and the scale effect or on the cumulative effect induced by GDP on our considered type of CO_2.

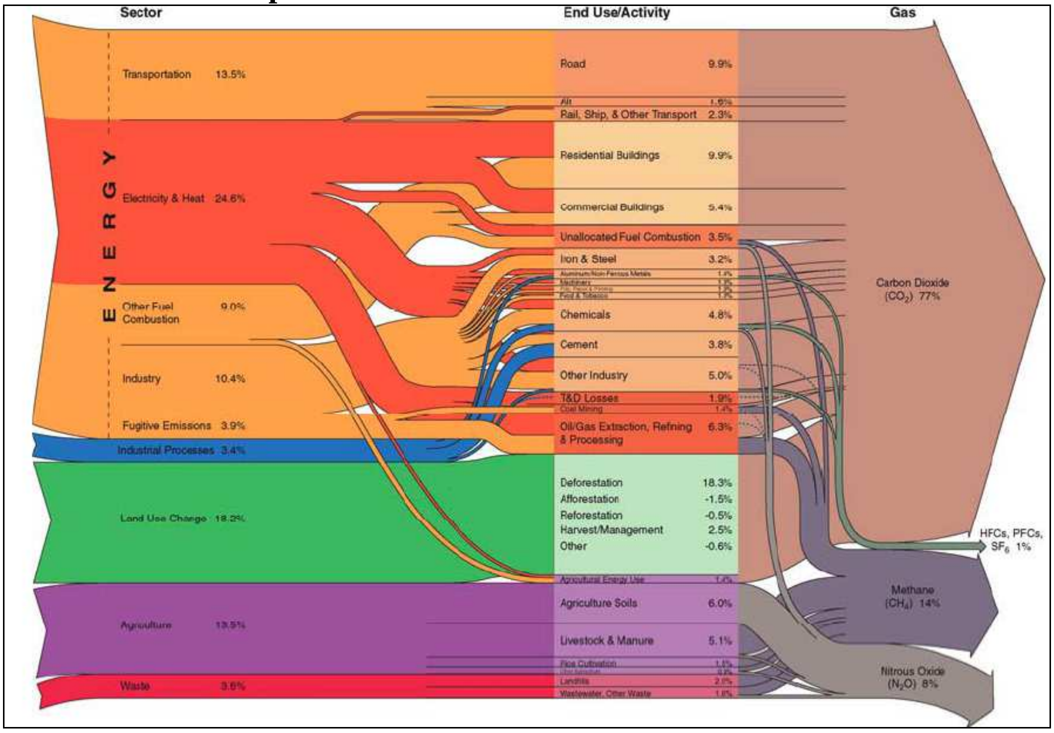
As anticipated in the previous section, this could be explained by the fact that the contribution of the agricultural sector to the generation of this type of CO_2 is very small. This misleading aspect of our analysis can be easily observed in a couple of graphs. The two charts below (graph 3.7 and graph 3.8), produced by the WRI for 2000 and 2005, show that the world contribution of agriculture to the generation of CO_2 from energy use is about 1.4% of the total emission[80]. Seen from this perspective, CO_2 cannot be considered as a type of pollutant particularly

[79] In Jorgenson's work CO_2 was considered as the amount of emissions from agricultural production as a whole. We have used, instead, data associated to the amount of CO_2 generated in the "agriculture and fishing" sector as a result of fuel combustion activity.

[80] We do not have similar detailed computations for the OECD countries. The only OECD country for which computations of this kind were made in 2005 is the U.S.A., thanks to the activity run by the WRI. The U.S.A. data also shows the irrelevance of agriculture in contributing to the generation of CO_2 emission from energy use and fuel combustion (www.wri.org/chart/us-greenhouse-gas-emissions-flow-chart). Nevertheless, it is interesting to investigate CO_2 since it is considered as the most significant GHG contributing to global warming (IPCC, 2007).

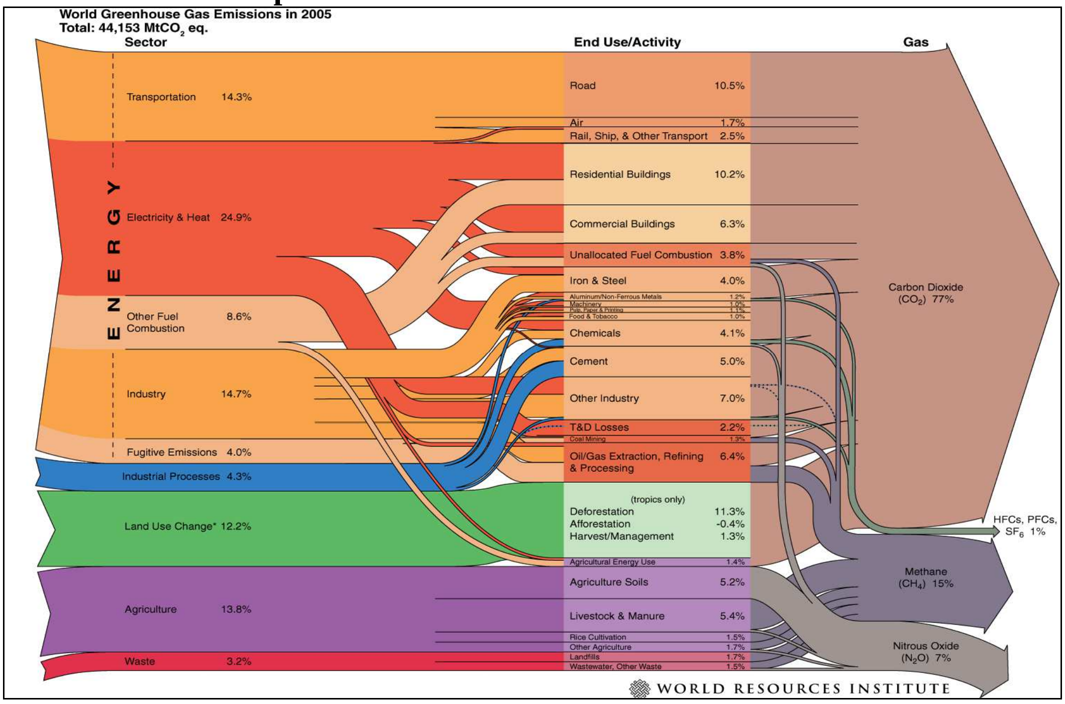
associated to agricultural activities and its consideration surely represents the misleading aspect of our analysis.

Graph 3.7 – World Green-House Gases at 2000.



Source: Baumert et al., 2005, p. 14.

Graph 3.8 – World Green-House Gases at 2005.



Source: Herzog, 2009, p. 2.

3.3.3.2.3. The impact of FDI on CO_2 through GDP.

We are unable to comment on the impact of FDI on CO_2 through GDP, since the CO_2-GDP and the CO_2-GDP^2 relationships were both found to be statistically insignificant. As already said in the previous section, the fact that GDP is unable to statistically explain a relationship with the sectoral CO_2 from fuel combustion may be due to the very small role it plays in its generation. As a result, we only rely on the direct relationship between CO_2 and FDI to have an idea of the impact the latter generates on the earlier.

3.3.3.2.4. The composition effect.

The composition effect, which we have considered in terms of relevance of the "agriculture and fishing sector" cannot be the subject of any comment because, once again, the various estimation attempts of model [2] did not produce any statistically useful evidence.

3.3.3.2.5. Other evidence.

We have already said in commenting the results achieved by analyzing model [2] that the variables represented by market openness, education levels and the size of protected areas were not found to be statistically significant.

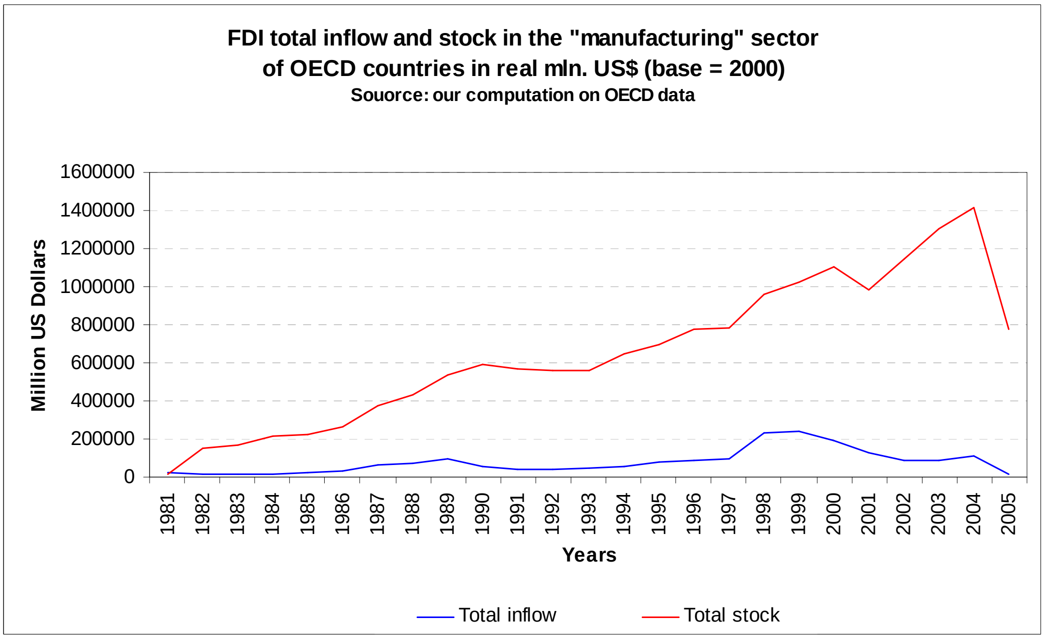
The only noteworthy result of this further estimation work can be seen in the negative relationship between CO_2 emissions and the cross-product we used, which makes us observe how an increase of the sectoral GDP causes a decreasing impact of the total inflow of FDI on our considered dependent variable. As done in the previous section, we can comment on it while referring to two different aspects. On the one hand, we can refer to it in terms of a very broad substitute of what we have missed to observe in relation to the examination of the effect of FDI on CO_2 through the sectoral GDP. In this sense, the algebraic sign of the relationship remains negative and indicates an inverse relationship between FDI and CO_2. On the other hand, it might be intended as a general indication of a composition effect, since it gives an idea of how the emission level associated to our considered polluting agent changes in response to modifications of the relevance of the sector subject of investigation. The policy indication arising from these considerations would suggest the adoption of an approach oriented to the increase of the sectoral FDI inflow and/or of the relevance of the considered sector because they are beneficial to the environment, this intended in terms of reduction of CO_2 emissions from sectoral fuel combustion.

3.4. The analysis of the "manufacturing" sector.

The increasing relevance of the "manufacturing" sector *stricto sensu* in the OECD area is shown by the data from the United Nations. We observe how, over the 25-year period considered in our study, the sector developed from 19.27% of the total GDP in 1981 to 22.92% in 1993 to finally reach 24.78% in 2005. As such, it is natural to perceive this sector as one attracting a significant quota of FDI and, at the same time, relevantly contributing to pollution. As before, with the aim of better introducing the major arguments devoted to the analysis of the FDI-environment relationship in the "manufacturing" sector, we now present the trends of the sectoral FDI flows and stocks between 1981 and 2005. Afterwards, the reason for choosing CO_2 from fuel combustion deriving from the sectoral activities and its trend over the considered period is also presented.

With regard to the first aspect, the figure below (graph 3.9) shows both the trends of the FDI flow and stock (or inward position) in the “manufacturing” sector, which derive from the year by year aggregation of the data of the 30 OECD considered countries (see tables III.5 and III.6 in the appendix section). Although the occurrence of various gaps in the dataset and some uncertainty in data computation at source generate some difficulty in dealing with this information, we can observe how over the considered period the trend of the sectoral inflow of FDI fluctuated over a range of values. Its minimum level of about 15,891 million US$ was seen in the first part of the considered period in 1982. The maximum level was recorded in 1999 with an inflow of FDI of about 239,669 million US$, which fell again to a new minimum of about 17,672 million US$ in 2005. The observation of the data aggregated by country highlights that the major investment receiving countries over all the considered period are the USA (with about 875,736 million US$), followed by the United Kingdom (with about 167,016 million US$), France (with about 130,694 million US$) and the Netherlands (with about 122,257 million US$). Apart from Luxembourg, for which we do not have any recorded data, the countries which received the minor quota of investment, instead, are: New Zealand (with about 761 million US$), Slovak Republic (with about 1,394 million US$), Iceland (with about 1,569 million US$) and Austria (with about 3,123 million US$).

Graph 3.9



In relation to the trend of the FDI stock, observation of the data summarized in the above graph shows a general increase – although with a few fluctuations – in all the OECD area from a minimum of about 15,798 million US$ in 1981 to about 778,008 million US$ in 2005. The year corresponding to the major level of capitalization, however, is 2004 with the highest peak of about 1,417,236 million US$. Observation of the evolution of the stock trend by country during the whole considered period highlights how the USA (with about 6,277,658 million US$), the United Kingdom (with about 1,696,917 million US$), Canada (with about 1,402,707 million US$) and the Netherlands (with about 1,289,547 million US$) are those countries which have capitalized the major quota of FDI stock. Apart from Belgium, Ireland, New Zealand and Spain, for which we do not have records, the last positions in the ranking of FDI stock receiving countries are Iceland (with about 5,905 million US$), Slovak Republic (with about 8,559 million US$) and Luxembourg (with about 40,315 million US$).

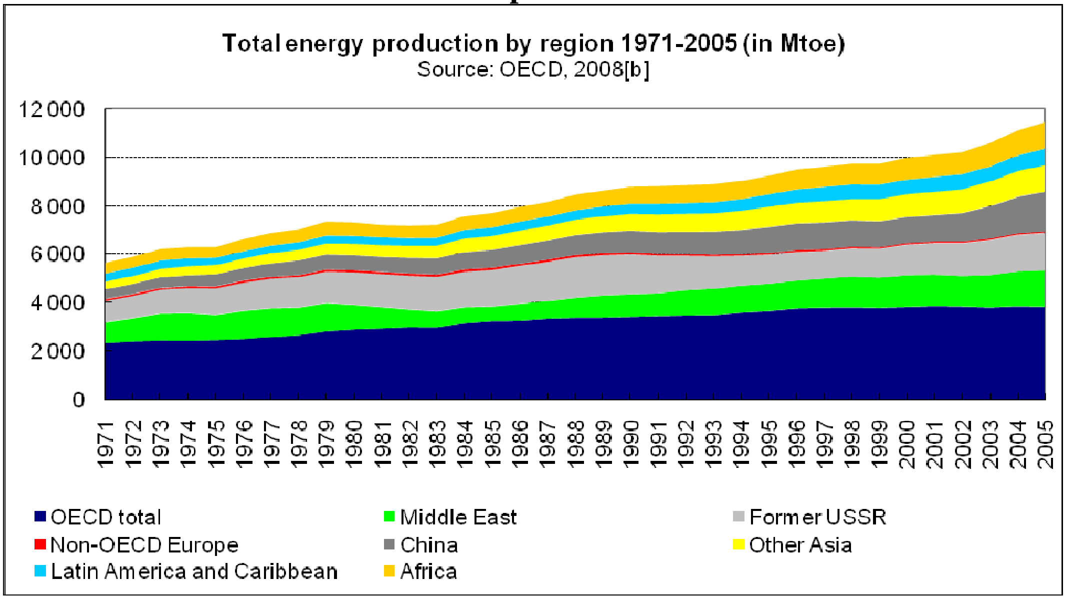
In explaining why CO_2 from sectoral fuel combustion was chosen as the polluting agent in our empirical analysis, it is important to say that industrial manufacturing activities rely heavily on the use of energy. This is mainly generated through processes of fuel combustion and, in turn, is responsible for the largest amount of greenhouse Gases (GHGs) emissions, CO_2 being among these[81]. In fact, about a third of the world's energy consumption and 36% of CO_2 emissions are generated by manufacturing industries. The large primary materials industries (i.e. chemical, petrochemicals, iron and steel, cement, paper and pulp, and other minerals and metals) account for more than two-thirds of this amount (IEA, 2007[b]). The link between manufacturing activities and CO_2 emission is easy to see if we also consider that in 2005 the concentration of CO_2, which was equal to 379 parts per million in volume (ppmv), was about 35% higher than a century and a half ago, that is the pre-industrialization era, when the rather steady level of concentration was about 280 ppmv (IEA, 2011, 2009, 2007[a]).

With the aim of better commenting on the triple relationship between energy use, manufacturing industry and CO_2 generation, we now analyse some data and begin with that reported by the OECD related to the world total energy production by region for the period between 1971 and 2005. We do so because energy production is considered as a function of the natural resources availability of a country and can represent an economic incentive for their exploitation and use (OECD, 2009). From the graph below (graph 3.10), it is possible to observe how world energy production has continued to increase during the considered period moving from 5,655 Mtoe in 1971 to 7,217 Mtoe in 1981 and again to 8,901 Mtoe in 1993 to end in 2005 at 11, 468 Mtoe. It is also possible to observe how a very significant quota of the world production (39% as an average over all the period

[81] We have already noted in a previous section that the long-living GHGs are CO_2 (Carbon dioxide), CH_4 (Methane), N_2O (Nitrous Oxide), O_3 (Ozone) and, according to some scientists, water vapour. Here, we highlight that CO_2 is the most significant GHG contributing to global warming and climate change (IPCC, 2007).

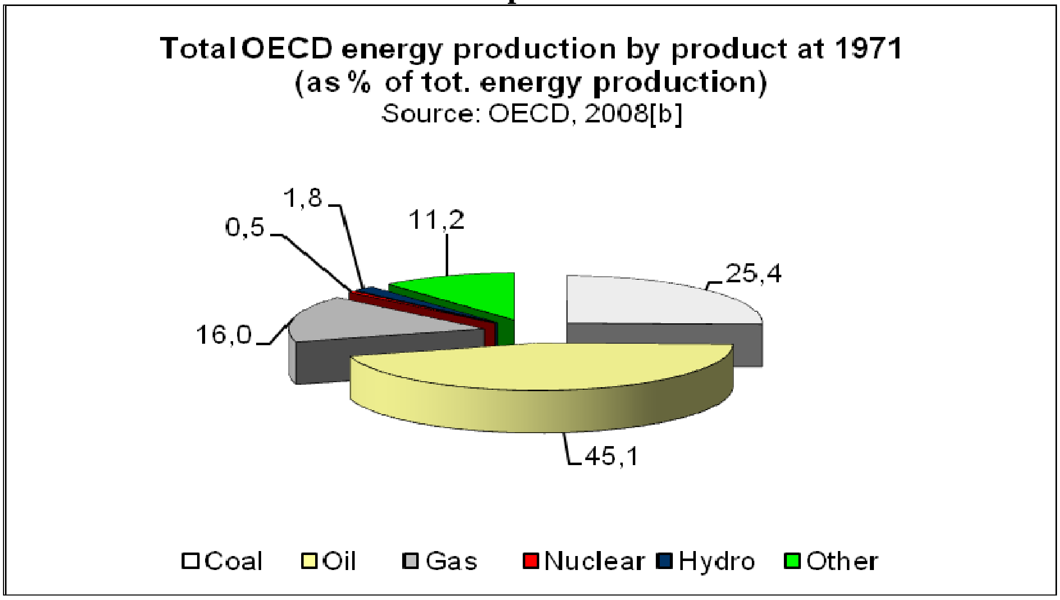
considered in the graph 1971-2005) has been ensured by the countries of the OECD area. More specifically, the OECD production – generally increasing, although at a slower pace with respect to the growth of world production – has always represented a relevant contribution to total world production during the period in question, moving from 2,343 Million tonnes oil equivalent (Mtoe) in 1971 (when it represented 41.4% of world production) to 2,943 Mtoe in 1981 (40.8% of world production) and to 4,486 Mtoe in 1993 (39.2% of world production) to reach 3,834 Mtoe in 2005 (33.43% of world production) (OECD, 2008[b]).

Graph 3.10



Moving now onto scrutinizing the data dispatched by the OECD (2008[b]) on the type of product, where the production of energy comes from, the two graphs below (graph 3.11 and graph 3.12) – in the absence of a complete time series – give us the possibility of comparing two situations at the extreme points of the time span subject of consideration. Although the first considered year (1971) does not exactly correspond to that representing the starting point of the time span we consider for our empirical analysis (1981), it gives us the possibility of observing how the dynamic related to the type of products used for energy production changed up to 2005. As can be seen, in 1971 the most significant part (45.1%) of energy produced in the OECD area was from “oil”, 25.4% from “coal”, 16% from “gas”, 0.5% from “nuclear”, 1.8% from “hydro” and 11.2% from “other” products or sources (geothermal, wind, solar, etc.).

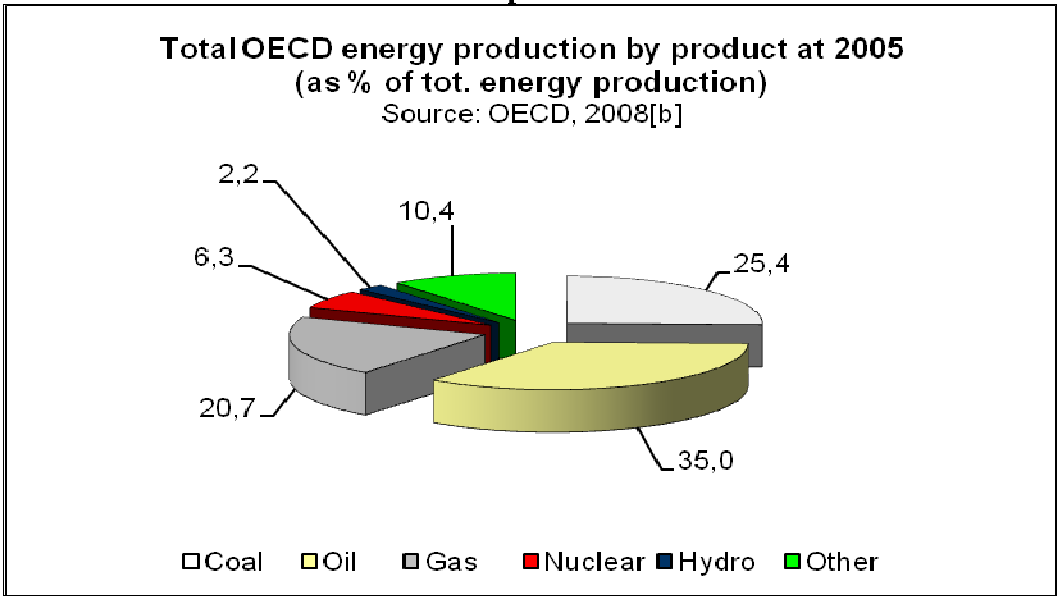
Graph 3.11



As can be appreciated from the data just presented, in 1971 a quota of 70.5% of the energy produced in the whole OECD area comes from the use of fossil fuels, whose combustion is the most relevant CO_2 generator. Examination of the data at 2005 allows us to observe a little change. In fact, the production of energy from “oil” shows a decrease to 35%, production from “coal” is substantially unchanged remaining 25.4% of the total energy produced. An increase can be observed in the use of “gas” for energy generation which now results 20.7%. An increase to 6.3% can be observed in relation to “nuclear”. In addition, a very slight increase is shown with regard to “hydro”. Very slightly decreased (10.4%) is the contribution made by “other” sources to the OECD energy production (OECD, 2008[b])[82].

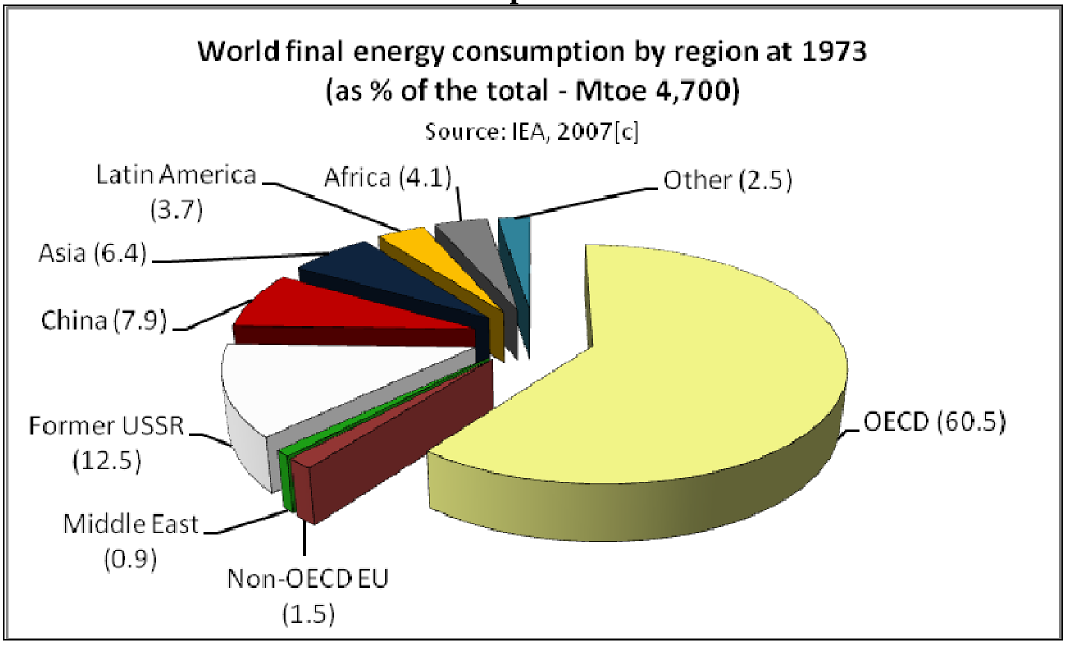
[82] According to IEA (2007[c]: 30), under the label “other” in graphs 3.11 and 3.12 we classify world marine bunkers.

Graph 3.12

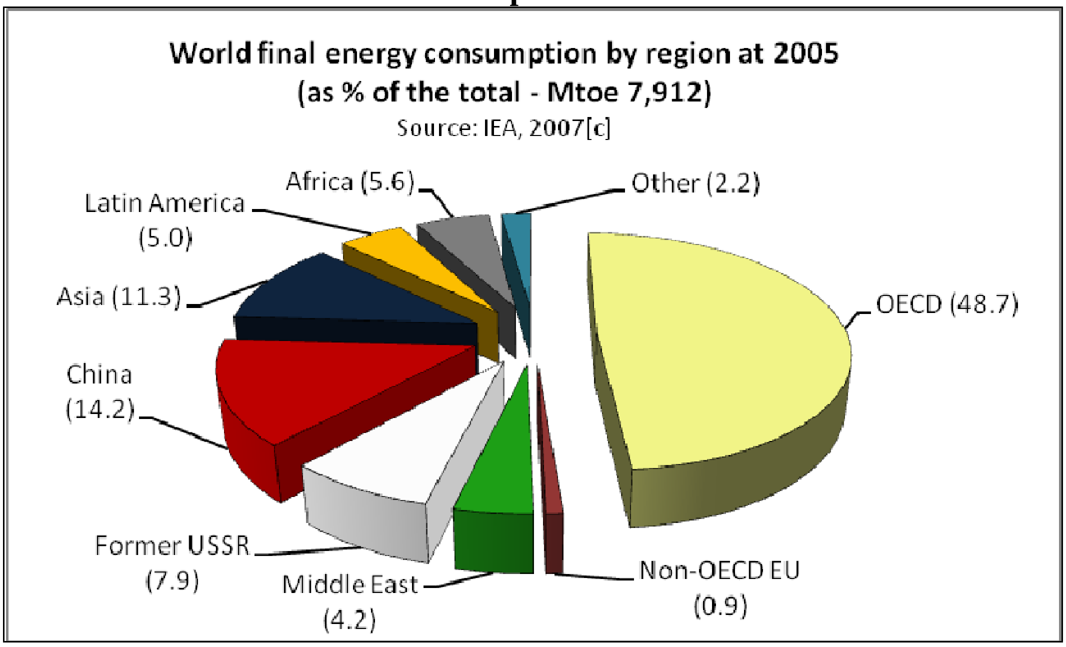


Even the analysis of the data related to the energy consumption shows the relevant contribution of the OECD area in the world scenario and – within the OECD area – the relevant use of fossil fuels (particularly oil) as primary energy vector. Data computation from the International Energy Agency (IEA) helps us to observe the situation at two specifically considered years, namely 1973 and 2005 (IEA, 2007[c]). Once again, although the first considered year (1973) is not exactly the starting point of the time span we consider for our empirical analysis (1981), it is useful to understand how the energy consumption dynamic evolved in the decades leading up to 2005. More specifically, if we look at the following graph (3.13), which gives us a picture of the situation at 1973, we can appreciate how in the world context, the OECD countries already represented the main energy consuming area with 60.5% of the worldwide final energy consumption corresponding to 4,700 Mtoe. At that time the OECD area was followed by the former USSR and China with 12.5% and 7.9% of the final energy consumption respectively. A different situation is observed at 2005 (graph 3.14), when the OECD countries were confirmed as the main energy consumers worldwide with their consumption level being 48.7% of the total world final energy consumption equal to 7,912 Mtoe. They were primarily followed by China (14.2%) and the rest of the Asian countries (11.3%).

Graph 3.13

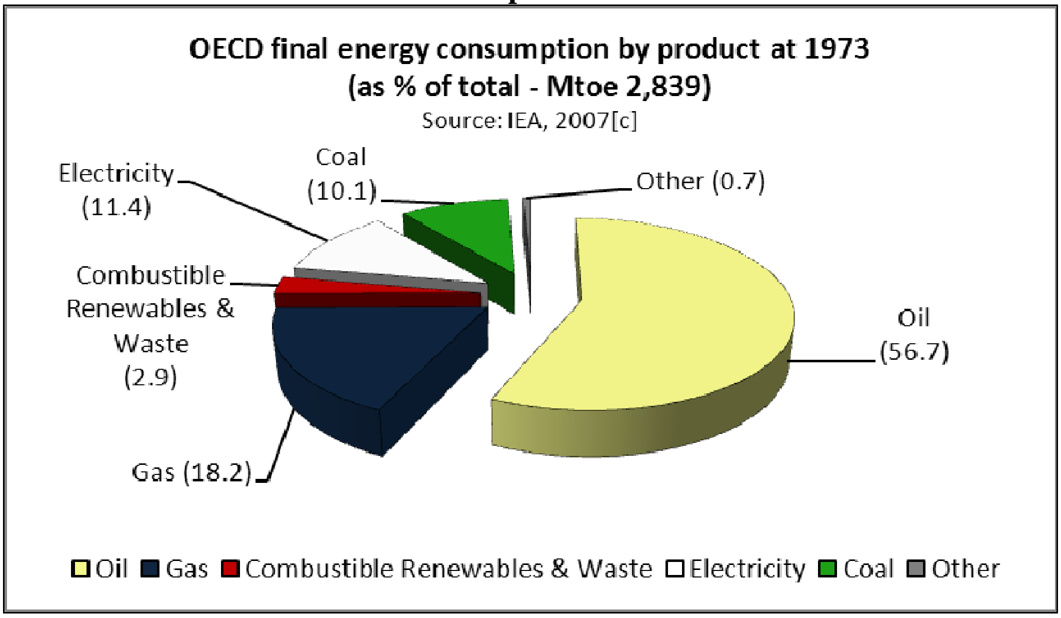


Graph 3.14

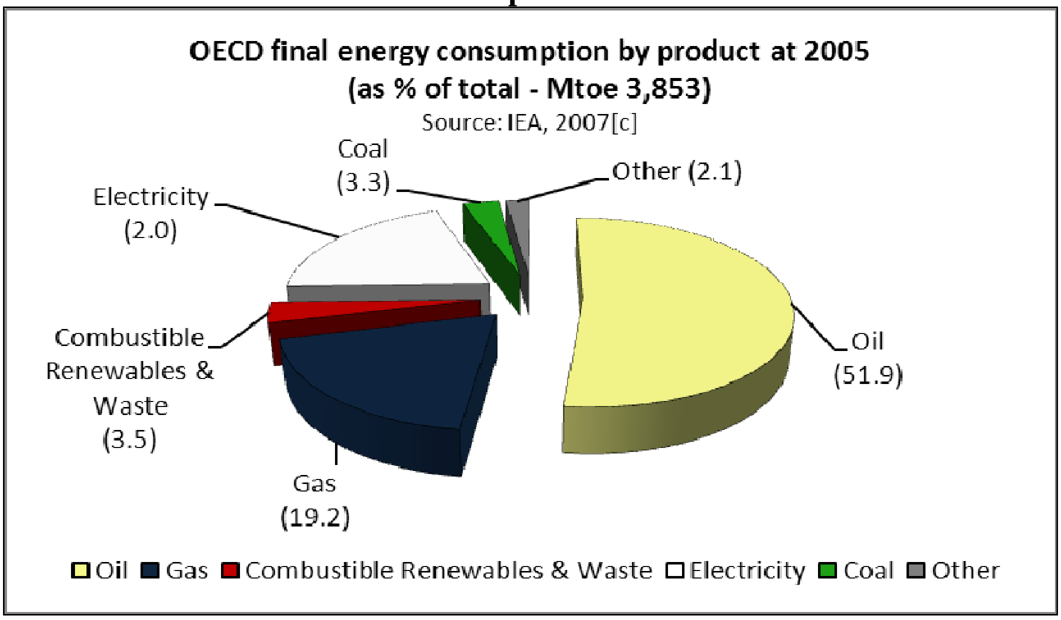


With respect to the origin of the energy consumed in the OECD area, the following graph (3.15) shows that in 1973 fossil fuels were the major energy vector representing 66.8% of the total final energy consumption equal to 2,839 Mtoe. More specifically, 56.7% of the final energy consumption is generated by the use of oil and 10.1% from coal[83]. At 2005 (graph 3.16), the energy consumption from the use of fossil fuels was 55.2% of the total (3,853 Mote) and more precisely, 51.9% from oil and 3.3% from coal (IEA, 2007[c]).

Graph 3.15



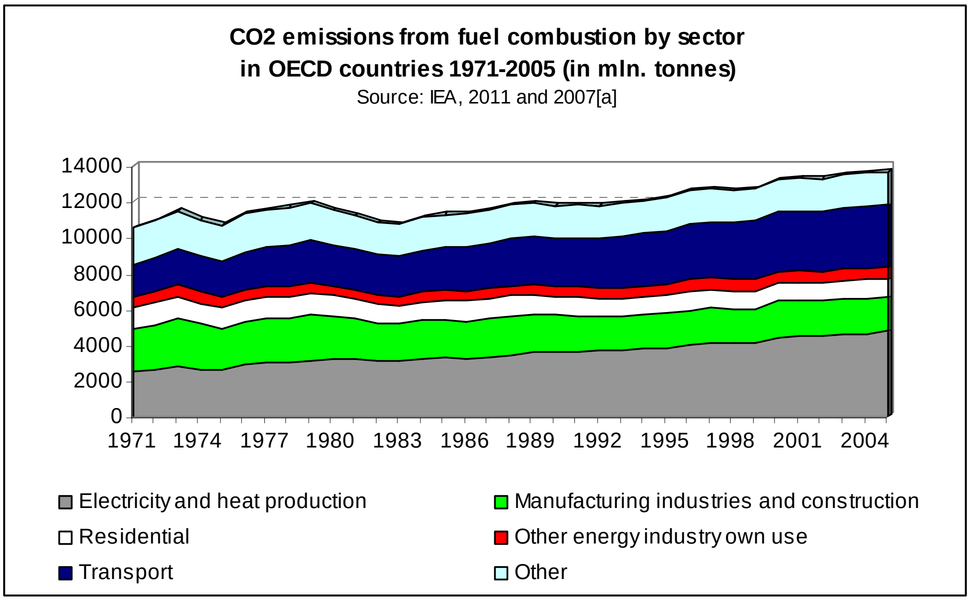
Graph 3.16



[83] In graphs 3.15 and 3.16 the label "other" is mainly for geothermal, solar, wind and heat energy vectors (IEA, 2007[c]: 29).

Moving now onto specifically considering the aspect related to the CO_2 emission from fuel combustion, computations on data from IEA make us observe how in the OECD area its level was, on average, equal to 56.5% of the world total between 1971 and 2005 (IEA, 2011). Furthermore, the graph below (graph 3.17) shows the contribution of some considered sectors to the generation of CO_2 from fuel combustion in the OECD area. Apart from highlighting the general increase characterizing all the considered sectors, it makes us observe how the sectors of "electricity and heat generation", "transport" and "manufacturing industries" are the main anthropogenic contributors to CO_2 emissions from fuel combustion.

Graph 3.17

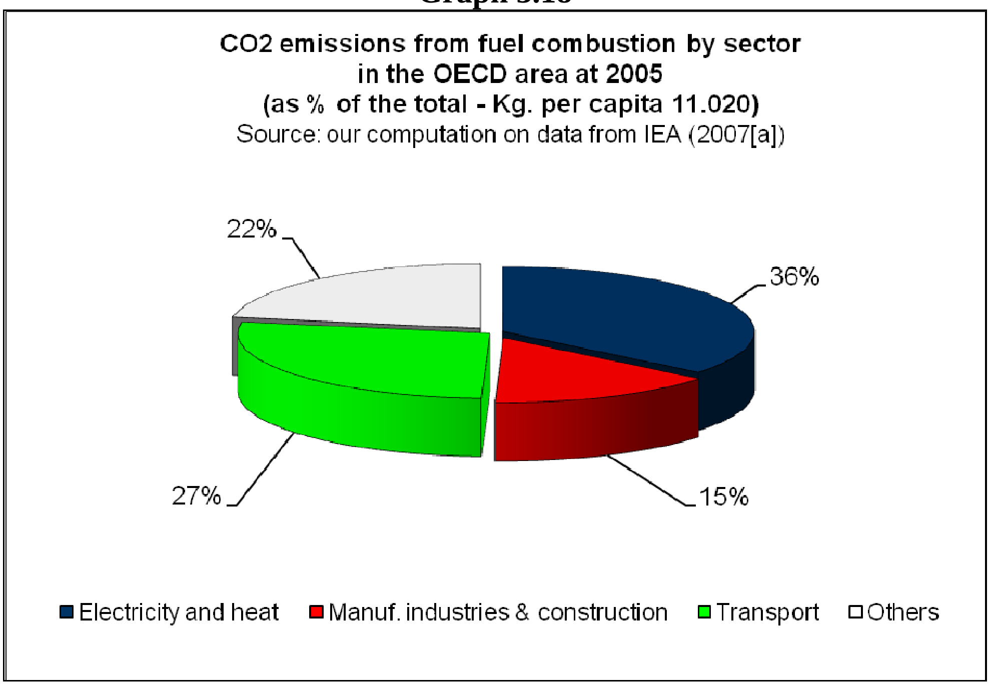


More specifically, the "electricity and heat generation" sector emitted, on average, about 3,517.26 Mtoe per year between 1971 and 2005, that is 57.9% of the total world emission associated to the sector in question. The other sector identified as "other energy industry", instead, generated about 605.9 Mtoe as a yearly average, this corresponding to an average of 59.6% of the sectoral world emission. Furthermore, with reference to the whole period we are considering, we can observe how the "manufacturing and construction" sector generated, on average, 2,146.3 Mtoe per year, which corresponds to about 47.9% of the world sectoral figure. The "transport" sector generated an average per year quantity of 2,659.8 Mtoe of CO_2, this being – always in terms of average – about 60.6% of

CO_2 emissions from fuel combustion generated at world level in the same considered sector. The "residential" sector emitted an average of about 1,090 Mtoe per year, corresponding to about 64.3% of the sectoral world considered type of emission. Lastly, the sector generically labelled as "other", which includes among its main voices "commercial and public services", "agriculture and forestry", "fishing", "other energy industries" and "other emissions not specified elsewhere", generated, on average, about 1,903.18 Mtoe per year during the considered period, this representing about 59.9% of the world total emissions of the considered pollutant in the same considered sectors (IEA, 2011; 2007[a]).

A more specific look at the situation associated to 2005 (graph 3.18), which is the last considered year in our analysis, makes us further observe how in the OECD area the "industrial manufacturing" sector – which is the sector subject to analysis and empirical investigation in this work – appears among those sectors relevantly contributing to CO_2 emissions from fuel combustion. With its 15%, it shows once again to be the third sector contributing to CO_2 emissions, just after the "electricity and heat generation" (36%) and "transport" (27%) sectors. They are all followed by the generic "other" sector (22%), which must be intended in the same way as mentioned above (IEA, 2009[a]; 2007[a]).

Graph 3.18

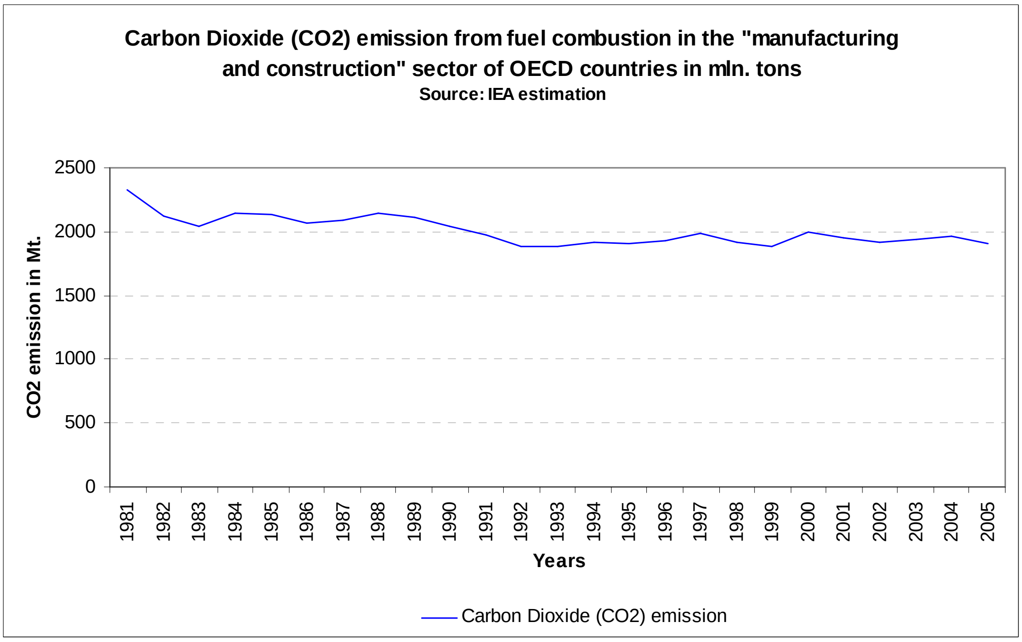


Before concluding this section, we give a look at the trend of CO_2 from fuel combustion in the "manufacturing and construction" sector between 1981 and 2005 in OECD countries. To this aim, we refer to the figure below (graph 3.19), which is built on the year by year aggregation of the data of the considered OECD countries (see table III.7 in the appendix section) and dispatched by the IEA database. The figure shows a general decrease of CO_2 from fuel combustion in the sector over the considered period. In fact, the pollution level passes from 2,331.66 million tons in 1981 to 1,910.88 million tons in 2005. Specifically, the more evident fall actually occurs between 1981 and 1993 (when about 1,878 million tons were recorded); afterwards the trend shows a steady state until the last considered year, 2005. According to some authors, the declining trend of CO_2 emissions is explained by a general reduction in manufacturing energy intensity, which was most probably motivated by economic growth and increased energy prices (Torvanger, 1991).

As was referred earlier, two significant downturns can be seen in OECD CO_2 emissions, following the oil shocks of the mid-1970's and early 1980's (OECD, 2008[b]). These conditions surely became an incentive to invest in new technologies to ameliorate industrial processes. For other aspects, the observation made on the basis of the breakdown by country – built on the cumulative emission quantity over the whole period 1981-2005 – allows us to see how between 1981 and 2005, countries such as the USA (with about 17,125 million tons), Japan (with 6,751 million tons), Germany (with about 4,035 million tons), Canada (with about 2,228 million tons), France (with about 2,070 million tons) and the United Kingdom (with about 2,028 million tons) were the major contributors to the generation of the considered pollutant. Iceland (with about 14 million tons), Luxembourg (with 90.63 million tons), Ireland (with about 134 million tons), New Zealand (with about 144 million tons) and Denmark (with about 145 million tons) result the least polluting[84].

[84] By referring to the already-mentioned table III.7 in the appendix section, it is interesting to note that if we end our observation at the last year considered in our analysis (2005) and normalize the emission quantities on the basis of the considered countries' population, the major CO_2 polluting countries are Luxembourg (with about 1.98E-04 million tons per capita), the Czech Republic (with about 1.05E-04), Belgium (with 8.25E-05) and Canada (with about 6.91E-05).

Graph 3.19



So far we have observed how the inflow and stock of FDI reaching the "manufacturing" sector of OECD countries have developed during the considered period. Furthermore, we have discussed some features characterizing the relationship between the "manufacturing" sector and CO_2 to explain the reasons for choosing CO_2 from fuel combustion deriving from the sectoral activities as the considered polluting agent. We have also observed its trend over the considered period. We now proceed as follows. In the next subsection we will describe the modelling approach of our empirical work dedicated to the sector in question. Afterwards, in another two subsections, the results of our analysis and a concluding discussion together with the identification of policy implications will be reported.

3.4.1. The modelling strategy description.

As already anticipated, the impact FDI exerts on the natural environment when entering the "manufacturing" sector of the OECD area is here investigated in terms of the relationship between the sectoral inflow of FDI reaching the countries of the considered area and CO_2 from fuel combustion deriving from sectoral activities. To this purpose, we have built an unbalanced panel dataset containing 24 variables which have all been tried in numerous analysis attempts. Only some of them have only been found significant and helped us to explain the above-mentioned relationship. The table below (tab. 3.13) reports the specification of only those variables which gave us the possibility of identifying the best fit model among the many attempts we made. In the right-hand column of the table, their source is also highlighted.

Tab. 3.13 – Variable specification for model [3][85]

No.	Variable	Description	Source
1	CO_2sctr	Dependent variable. Natural log. of the ratio between the amount of carbon dioxide (in million tons) from fuel combustion in the sector and the amount of workers in the sector.	Our computation on IEA estimation and UN data
2	GDPsctr	One-year lag of the natural log. of the ratio between the sectoral GDP (in real US$) and the amount of workers in the sector.	Our computation on UN/OECD data
3	$GDPsctr^2$	Square of the natural log of the sectoral GDP (ln GDPsctr * ln GDPsctr) per worker in the sector (in real US$).	Our computation on UN/OECD data
4	FDIsctr	One-year lag of the natural log. of the ratio between the FDI inflow in the sector (in real mln. of US$) and the amount of workers in the sector[86].	Our computation on UN/OECD data
5	$FDIsctr^2$	Square of the natural log. of the sectoral FDI inflow (ln FDIsctr * ln FDIsctr) per worker in the sector.	Our computation on UN/OECD data
6	GCF	Natural log. of the ratio between the amount of Gross Capital Formation (in real US$) and the total no. of work force (in thousands).	Our computation on WB, ILO
7	SCTRrel	Natural log. of a sectoral relevance indicator given by the ratio between the sectoral GDP (in real US$) and the total GDP (in real US$).	Our computation on UN data
8	MKTopn	Natural log. of a market openness indicator given by the ratio between the sum of the export and the import (taken in absolute terms) both considered f.o.b. (in real US$) over total GDP (in real US$).	Our computation on IMF/UN data
9	PROTarea	Natural log. of the surface of protected area (in squared Km.).	Our computation on UN data
10	EDU	Natural log. of the average year of school indicator.	Our computation on CID Harvard data
11	CRpr	Natural log. of the cross-product derived from the amount of GCF (in real US$) times the total FDI inflow (in real mln. US$).	Our computation on WB/OECD data

We have already introduced the main aspects of our modelling strategy approach in section 2. However, we again highlight that the functional form used

[85] As before, we specify that all the financial data was in US$ and was transformed from current to real terms by using the USA Gross National expenditure Deflator (base year = 2000) gathered from the World Bank database available on line at http://databank.worldbank.org

[86] For the reasons already cited in the previous chapter and in a footnote at the beginning of the previous section, we make the flow and not the stock of FDI subject of attention in our empirical task.

for our empirical task is of log-log type and considers the variables in first-differences for the reasons already said in the previous sections[87].

[3] $CO_2sctr_{it} = \alpha + \beta_1\, GDPsctr_{it} + \beta_2\, GDPsctr^2_{it} + \beta_3\, FDIsctr_{it} + FDIsctr^2_{it} + \beta_4\, GCF_{it} + \beta_5\, SCTRrel_{it} + \beta_6\, MKTopn_{it} + \beta_7\, PROTarea_{it} + \beta_8\, EDU + \beta_9\, CRpr_{it} + \varepsilon_{it}$

where: ***i*** represents the cross-sectional units related to our 30 OECD countries; ***t*** is the time dimension referring to the years considered in our time span, that is from 1981 to 2005; $\boldsymbol{\varepsilon}$ is the error term. While inviting the reader to refer back to the table above (tab. 3.13) for the description of the variables in the equation, it is useful to highlight how the induced-GDP and the induced-FDI technique, scale and composition effects are identified in this equation model. According to what has already been said, where the literature inspiring our work was examined, the technique effect is identified through the estimated β_1 that is coefficient of the per-capita GDP variable taken in isolation, since it happens as a result of a change in the income level. The scale effect, representing the size of the considered countries' economic expansion, is instead observed through the coefficient of $2\beta_2$ *GDP* which is obtained by computing the partial derivative of our equation [3] with respect to GDP[88]. Finally, the induced-GDP cumulative or total effect is achieved by bringing to solution the result of the partial derivative of the equation model [3] with respect to GDP. It can be observed through the coefficients of $\beta_1 + 2\beta_2\, GDPsctr$ in elasticity terms and computed, for example, while substituting GDP with the sample mean income of our OECD countries observable in the following table 3.14 (e.g. Managi et Al., 2008; Liang, 2006; Cole & Elliott, 2003; Antweiler et Al., 2001).

[87] As done before, we recur to transform our variables into first-differences as a consequence of the result of the Engle-Granger test for cointegration we ran on the OLS model while considering our variables in levels (Engle & Granger, 1987). The lagged value of the residuals $\hat{e}$ shows a p-value equal to 0.0976 which makes us accept the null hypothesis of no-cointegration.

[88] As in the previous section, we here comment on some results and highlight that the consideration made by Cole and Elliot (1993), that in the real world the scale effect is likely to be contemporaneous whilst the technique effect is likely to be the result of a past dynamic (which would suggest diversifying the considered variables by using lagged forms), can be seen as valid for the induced-GDP and the induced-FDI technique and scale effect. In fact, the coefficients identifying the technique effects (for GDP and FDI) are found significant while considering the variables at time *t-1*. The induced-GDP and induced-FDI scale effects are found significant while considering their respective variables at time t.

Similarly, the coefficients of the induced-FDI technique, scale and their cumulative effects on our considered environmental variable are respectively observed through β_3, $2\beta_4\,FDIsctr$ and $\beta_3 + 2\beta_4\,FDIsctr$ (the latter two achieved by taking the partial derivative of equation [3] with respect to FDI) and, for their actual computation, while substituting *FDIsctr* with the sample mean of the sectoral FDI inflow in OECD countries in the table giving the summary of the statistics.

The composition effect is captured in this model by considering two different aspects, which refer to the capitalization levels of the considered economies and the relevance of their "manufacturing" sector. More specifically, these two aspects are considered by the capital-labour ratio and by the ratio between the sectoral and total GDP (namely variables no. 6 and no. 7 as previously reported in table 3.13).

A final explanation for the employment of a cross-product in our estimation can be given in the same terms as before. The addition of nonlinear functions such as squares and cross-product to the objective function can help to test with power to detect ignored nonlinearities in model estimations (Wooldridge, 2002).

3.4.2. Results of the analysis.

The results are achieved by using the software package Stata/IC 12.1 for Windows. We begin their presentation by reporting the table below (tab. 3.14), which summarizes the main statistics of the variables considered in our model.

Tab. 3.14 – Summary statistics of the variables considered in the model [3].

Variable	Obs	Mean	Std. Dev.	Min	Max
Id	750	-	-	1	30
Year	750	-	-	1981	2005
EDU	750	2.12257	.2730594	1.029619	2.505526
CO_2sct **(dependent var.)**	678	-12.44676	.5173222	-13.56653	-10.19306
MKTopn	662	-1.735082	3.153601	-14.79678	4.411031
GCF	657	22.67215	.6319137	20.43895	23.74382
SCTRrel	641	1.730326	.2499945	-.7751441	2.502773
CRpr	608	30.9883	11.37811	-36.13007	40.98174
$GDPsctr^2$	591	332.2361	125.306	231.4286	873.3745
GDPsctr	590	18.0072	2.830883	15.21278	29.55291
$FDIsctr^2$	481	2.594019	4.148572	.0000769	40.2775
FDIsctr	480	-.4723731	1.543003	-5.067869	6.346456
PRTarea	480	-6.205169	1.807776	-9.219663	-1.6507

Before presenting the results achieved from the estimation of our model specification, we report on the outcomes of testing it for heteroskedasticity, autocorrelation and stationarity. Heteroskedasticity was tested by employing a LR test for the null hypothesis of panel homoskedasticity (Greene, 2007). It generated a chi2(26) = 1159.64 with a p-value = 0.0000, which make us reject the null hypothesis associated to the inexistency of heteroskedasticity and confirm that our model specification is affected by it. The autocorrelation was checked through a test developed by Wooldridge (2002) for panel data models, whose null hypothesis H_0 is associated to the inexistency of first-order autocorrelation. The result showed a F (1, 23) value = 16.261 and a p-value = 0.0005. As a consequence, we accept the alternative hypothesis of the test that our model specification is characterized by autocorrelation. The stationarity test was only run for those variables not considered in the previous analysis and performed through a Fisher test up to three lags (Maddala & Wu, 1999). We find evidence that the majority of our variables are non-stationary since we accept the null hypothesis that panels contain unit-roots every time the p-value $\geq$ 0.0005 (tab. 3.15).

Tab. 3.15 – Fisher test for panel unit-root using an augmented Dickey-Fuller test.

Variable	Lag -1	Lag -2	Lag -3
	chi2	*chi2*	*Chi2*
	p-value	**p-value**	**p-value**
CO_2sctr	*39.0495*	*42.2730*	*53.7422*
	0.9835	**0.9599**	**0.7023**
GDPsctr	*71.8290*	*49.1553*	*38.8956*
	0.1047	**0.7894**	**0.9746**
GDPsctr^2	*72.4776*	*49.2209*	*38.8116*
	0.0956	**0.7874**	**0.9752**
FDIsctr	*195.2725*	*87.6643*	*105.3609*
	0.0000	**0.0014**	**0.0000**
FDIsctr^2	*105.4533*	*218.2094*	*244.1989*
	0.0001	**0.0000**	**0.0000**
GCF	*48.7146*	*53.9064*	*54.0659*
	0.8024	**0.6282**	**0.6223**
CRpr	*123.2025*	*76.3031*	*60.3645*
	0.0000	**0.0369**	**0.3210**

** chi2 in italics, p-value in bold.*

We can now move onto commenting the estimation results of our considered model while considering data in first-differences to recover from the non-stationarity problem affecting our panel. The following table (tab. 3.16) shows Ordinary Least Squares (OLS), Fixed Effects (FE) and Random Effects (RE) estimates, which are corrected for heteroskedasticity and autocorrelation according to what has been done for models [1] and [2] in the previous sections[89].

Tab. 3.16 – Panel data estimation results for model [3].

CO_2sctr Dep. var.	OLS	FE	RE
GDPsctr	.0204*** (.0049091)	.0261*** (.0072365)	.0204*** (.0062818)
GDPsctr^2	.0027** (.0012774)	.0034** (.0014073)	.0027** (.0013852)
FDIsctr	.0058*** (.0019119)	.0060*** (.0015714)	.0058** (.0020706)
FDIsctr^2	.0007* (.0082222)	.0007* (.0088588)	.0007* (.0082899)
GCF	.1667** (.0763059)	.2042** (.0770512)	.1667 (.1034699)
SCTRrel	-.1360** (.055353)	-.1631*** (.0421495)	-.1360** (.0600196)
MKTopn	.0917* (.0493508)	.1154** (.0451816)	.0917 (.0562585)
PROTarea	.0052 (.0639517)	.0452 (.0480407)	.0052 (.0638302)
EDU	.2522 (.2401211)	.0525 (.05262638)	.2522 (.2405569)
CRpr	.0001 (.0003934)	.0001 (.0002219)	.0001 (.0001782)
Constant	-.0147*** (.0046204)	-.0162*** (.0058263)	-.0147*** (.0053518)
N. obs.	**277**	**277**	**277**
N. groups	**26**	**26**	**26**
R-squared	**0.1264**	**n.a. with robust estimates**	**Rho = 0**
Adj. R-squared	**n.a. with robust estimates**		

Robust standard errors in parenthesis; P-value: * ≤ 1%, ** ≤ 5%; * ≤ 10%**

Table 3.17 below shows the Brush-Pagan test (or LM test) results we use for the choice between OLS versus RE/FE. We observe a chibar2 equal to 0.00 with a p-value = 1.0000. As a consequence, we choose the OLS model as the reference for our comments[90].

[89] Similarly to what has previously been done, we decide to use first-differences after running the Engle-Granger test for cointegration on the OLS model while considering our variables in levels. The lagged value of the residuals $\hat{e}$ the test shows a p-value equal to 0.069 this implying that the residuals of the regression are non-stationary and its variables are not cointegrated.

[90] It is worth highlighting that this estimation shows a very high level of joint significance of the variables in the model since it performs a F(10, 25) = 43.95 with a p-value = 0.0000. In addition, we test the joint significance of the two variables associated to GDP and FDI respectively. GDP and its square are jointly significant with F(2, 25) = 5.60and and p-value = 0.0098. FDI and FDI squared are jointly significant with F(2, 25) = 8.43 and p-value = 0.0016. This implies that the consideration of these variables in our model makes it correctly specified.

Tab. 3.17 – The Brush-Pagan (LM) test results.

	Var	**sd = sqrt(Var)**
CO_2sctr	.0053985	.0734743
E	.0048397	.0695678
U	0	0
Test: Var(u) = 0	**chibar2(01)** = 0.00	**Prob** > **chi2** = 1.0000

We begin by observing a very high level of statistical significance (p-value = 0.000) and a positive relationship (0.0204) between CO_2 from the sectoral fuel combustion and GDP. A further statistically significant result (p-value = 0.036) and a positive correlation (0.0027) with CO_2 is observed when the GDP variable is considered in squared terms. We have already said in the previous pages that these two results are respectively associated to the induced-GDP technique and scale effects on our considered pollutant. More specifically, while the estimated β_1 (about 0.0204, namely the estimated coefficient of the GDP variable taken in isolation) represents the first type of effect, $2\beta_2$ *GDPsctr* (achieved from taking the partial derivative of equation [3] with respect to GDP) is the elasticity of the scale effect which is positive and equal to about 0.0027.

A first broad comment on the CO_2-GDP relationship, in light of these two results, would make us note that a rise in environmental degradation is the result of an early stage of income increase. Further improvements in the income level, however, would still generate a detrimental impact on the environment in terms of increase of the considered pollutant but at a slower pace. As a result, the cumulative or total effect of these two dimensions can be observed through the coefficients $\beta_1 + 2\beta_2$ (namely 0.0204 + 0.0054 *LnGDP*) obtained from the partial derivative with respect to *GDP* of equation [3]). It can actually be computed at the mean value while substituting *GDPsctr* with the mean of the income (18.0072) observed in table giving the descriptive of the statistics which gives a result equal to +0.1176. The environmental-economic meaning of the above-mentioned coefficients highlight how our considered pollutant changes in percentage terms in response to a 1% growth of GDP.

The main investigated relationship between the FDI variable and CO_2 emissions is found to be statistically significant (p-value = 0.002) and positive

(+0.0058) when the FDI variable is considered as it is[91]. The squared measure of FDI also appears to be statistically significant (p-value = 0.010) and highlights a positive relationship (0.0007) with CO_2. On the basis of these results and according to what has previously been said, we identify in the coefficient of the FDI variable taken in isolation, namely +0.0058, the technique effect of the CO_2-FDI relationship in our considered sector. The coefficients of the scale and the cumulative effects are represented by +0.0054 *LnFDI* and + 0.0204 + 0.0054 *LnFDI* respectively. Once again, the environmental-economic meaning of these coefficients is associated to the change of CO_2 in percentage terms in response to a change of the sectoral inflow of FDI of 1%.

The relationship between the variable associated to the capitalization level (considered in terms of GCF) of the analysed OECD countries' economies and the CO_2 emissions level is also found significant (p-value = 0.030) and positive (0.1667). Since the consideration of such an indicator – as already mentioned in the previous pages – is associated to the identification of one out of the two aspects of the composition effect in our model, we observe how an increase of the capitalization degree of our considered economies produces an increase - although only a very little amount - of the pollutant we are considering.

Significant (p-value = 0.015) and negative (-0.1360) is the coefficient describing the relationship between the variable measuring the relevance of the "manufacturing" sector and the level of CO_2 emissions. This result, representing the second aspect of the composition effect in our model, has the practical implication that a 1% growth of the sectoral relevance would generate a decrease of CO_2 emissions of about 0.14%.

The relationship between the variable measuring the level of market openness and the dependent variable is found significant (p-value = 0.064) and positive (+0.0917), this implying that a 1% increase in the degree of market openness would increase CO_2 emissions by about 0.1%.

[91] As in table 3.13, where the specification of the variables included in the model is reported, this FDI flow indicator is considered with a lag of one year for a better response of the model estimation. The justification for this would lie in the fact that changes in the FDI level exert their observed detrimental - although quantitatively scarcely significant - impact on the considered pollutant after one year from their implementation, probably due to the time needed by investment to enter appropriately into the work.

No comment can be delivered for the variables represented by the surface of the protected area and the education existing in our considered countries since they were found statistically insignificant. The same applies to the cross-product we have used in our model.

3.4.3. Discussion and conclusions.

The analysis developed in this section has evaluated an unbalanced dataset referring to 30 OECD countries for the period between 1981 and 2005 to primarily understand whether FDI inflowing in the “manufacturing” sector generates a detrimental impact on the environment, this considered in terms of CO_2 emissions from fuel combustion. To this purpose we have employed the econometric technique of panel data to test an equation model which is built, according to the mainstream literature, while taking into consideration "technique", "scale" and "composition" effects. The concluding considerations of its findings are given in the following sub-sections with the intention of presenting a discussion while considering the investigated variables grouped appropriately for the purpose of our analysis.

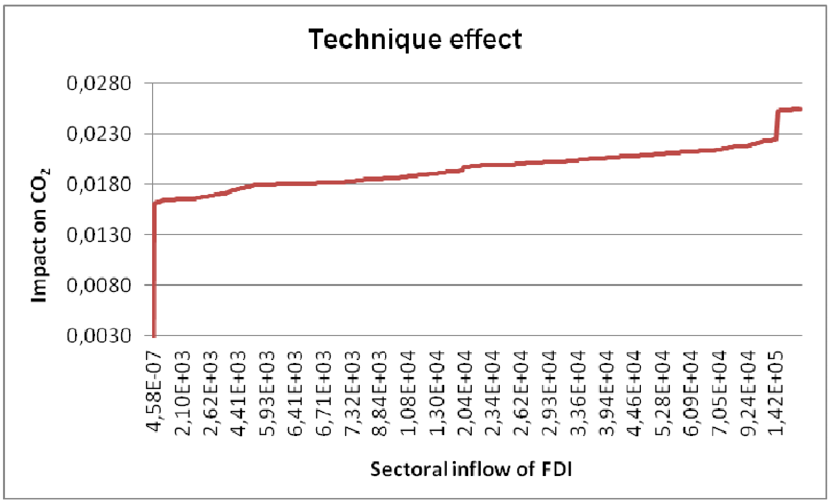
3.4.3.1. The induced-FDI technique, scale and cumulative effects.

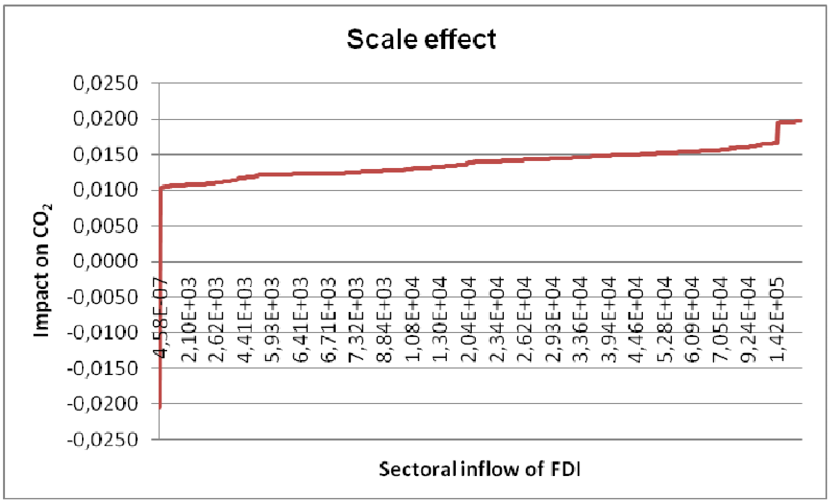
The discussion of the induced-FDI effects on CO_2 emissions from the sectoral fuel combustion is based on the observations of relationships which are algebraically characterized by positive signs. As has been seen in the section presenting the results of the empirical analysis, the technique effect - associated to the FDI variable taken in isolation - is represented by a coefficient equal to +0.0058. The scale effect - associated to the FDI variable squared - shows a coefficient equal to +0.0014. Both of these results show a detrimental effect of FDI on the environmental variable under consideration, although the latter highlights a slower pace than the earlier. In other words, when the scale of our considered economies increases, the CO_2-FDI relationship is still positive but the impact of FDI on CO_2 is reduced. As a result of these two positive relationships, the cumulative effect is also positive (since it is given by + 0.0058 + 0.0014

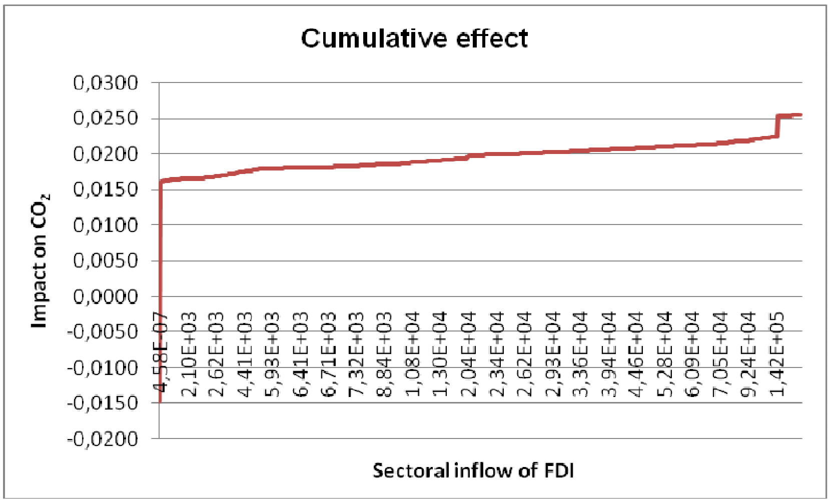
LnFDI and can be actually computed as averagely equal to +0.0051) and confirms the detrimental role of the sectoral inflow of FDI on the considered type of CO_2.

The graph below (graph 3.20) shows the trends of the induced-FDI technique, scale and cumulative effects on the level of CO_2 emissions from the sectoral fuel combustion we have found.

Graph 3.20







The graph helps us to observe more clearly the dynamic associated to the CO_2-FDI relationship. It shows an initial increasing trend due to the positive elasticity of the technique effect: CO_2 increases as a result of the sectoral inflow of FDI increase. Afterwards, when a turning point computed at the level of 1.59E-02 of FDI per-worker[92] in the sector is reached, the coefficient of the scale effect still remains positive but the relationship reduces its magnitude since it is characterized by a smaller number. As already argued, the overall impact of FDI on CO_2 remains detrimental to the environmental feature we are considering due to the positive sign characterizing the coefficient of the cumulative effect and resulting from the algebraic sum of the technique and scale effects both positive.

By referring back to what has been said in the chapter devoted to the literature review, our result confirms the evidence achieved in other studies where technique effects showing a positive relationship between FDI and pollution have been observed (e.g. Shahbaz et Al., 2011; He, 2006). This would imply that technology improvements implicitly associated to investment do not reduce the generation of a negative environmental impact. Furthermore, in relation to the scale effects, our evidence agrees with those views expressed in the literature which state that they are normally expected to be detrimental to the environment (e.g. O'Connor, 2000).

[92] The turning point is identified by taking the partial derivative with respect to FDI of our estimated function ($LnCO_2 = 0.0058\ LnFDI + 0.0007\ LnFDI^2$) and then making it equal to zero. The result is LnFDI = -(0.0058/0.0014) = -4.14 which converted into real numbers through exp(-4.14) gives 1.59E-02.

Having said this, however, a better look at the quantitative aspect of the coefficients we have found would induce us to partially retreat the considerations just made. It can be appreciated, in fact, how the technique, scale and cumulative effects we have achieved in our analysis are represented by such low numbers which would induce us to speak more appropriately in terms of an almost neutral role of FDI on the considered type of CO_2. This would also make us rehabilitate those considerations highlighting the positive role FDI plays on the environment. At the end of the day, we should still recognize the existence of a certain positive effect deriving from technology advances - implicitly associated to the investment dynamic - if our result is that of an almost neutral role of FDI on CO_2. Moreover, it cannot be left unconsidered that this is observed in the manufacturing sector which, as is broadly recognized, is very often based on production modes characterized by an intensive resource-use approach.

Having said this, even if we cannot speak in terms of the existence of an inverse relationship between CO_2 and FDI, we can surely argue in terms of the almost beneficial role investment plays on the environment. In this sense, our evidence can be seen as supportive of those views expressed in other studies. For example, work based on the use of the panel data technique and examining the impact of the FDI inflow on air pollution in China between 2001 and 2007 observes a significant causal effect showing the beneficial role FDI inflow plays in reducing air pollution (Kirkulak et al., 2011). The same evidence is reached by other studies, which have focused on the case of India and analysed a database containing a time series from 1980 to 2003, especially related to FDI inflowing into the country and CO_2 emission levels (e.g. Acharyya, 2009). As has been already said, what could help to explain the virtuous role of FDI inflowing in the OECD manufacturing sector on the CO_2 level can seen in the fact that FDI brings with it technological advances, which generate beneficial effects from an environmental point of view. Technology transfer can happen through four main channels, which in order of importance are: 1) vertical linkages with suppliers and purchasers in the host country; 2) horizontal linkages with competing or complementary companies in the same industry; 3) migration of skilled labour force; 4) internationalization of research and development activities. It is a general expectation that FDI activated by a MNE in a host country can result in technology spillover on domestic firms, which are pushed to adopt more modern technologies to improve their productivity – as well as environmental performance – to enter or stay in its market network (Johnson, 2006; OECD, 2002[c]).

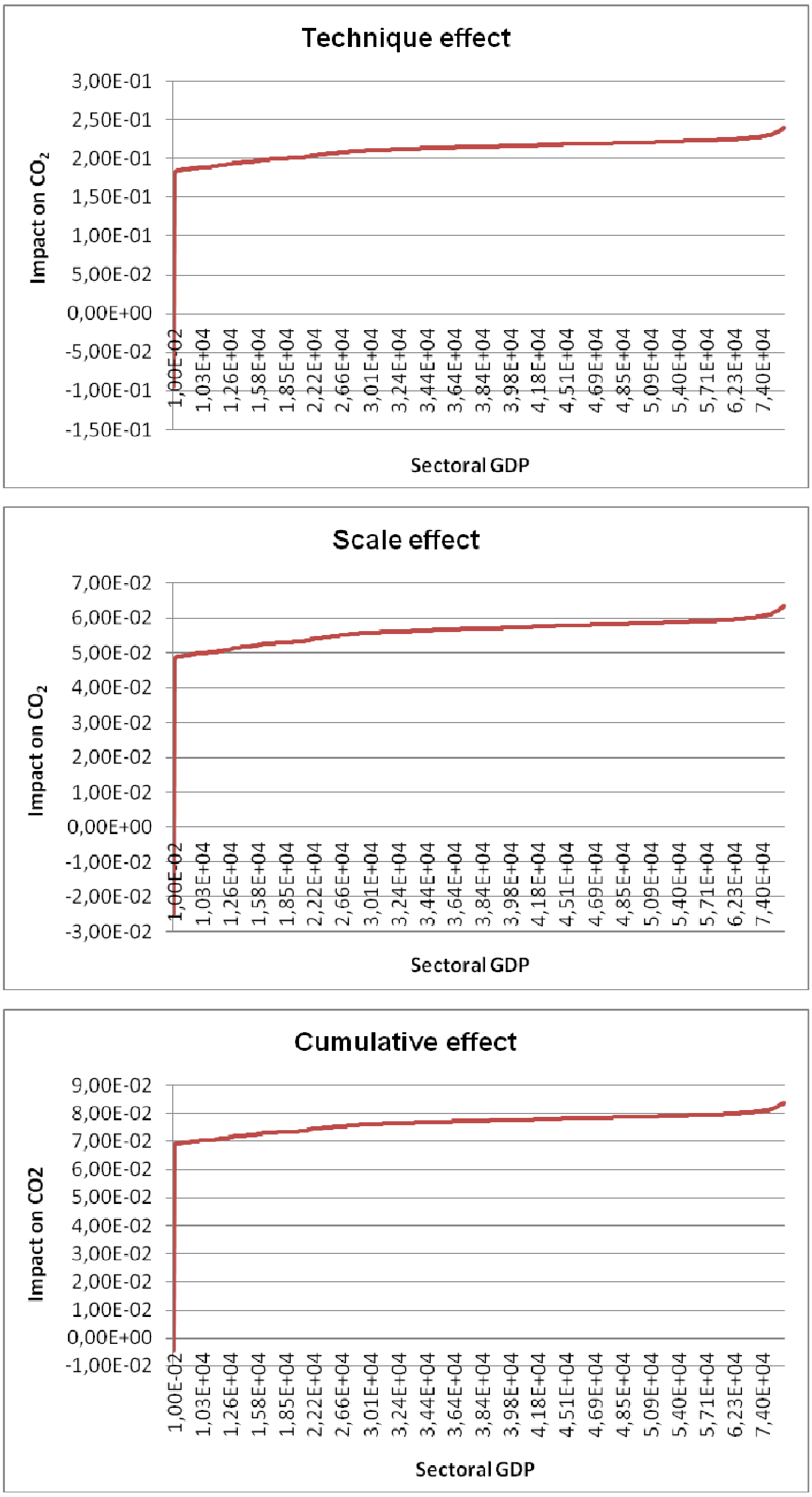
For a better understanding of the evidence we have achieved, namely the almost neutral impact FDI exerts on CO_2, it would also be valuable to look at the qualitative analysis of FDI inflow within the considered sector with the aim of observing whether the environmentally neutral role of FDI inflowing in the OECD countries is the result of the relocation phenomenon, whose mechanism attracts major investment quota into "less dirty industries" while pushing investment away from "dirtier industries" (i.e. Mani & Jah, 2006). Although this goes beyond the purpose of our work, it can certainly remain ascribed in the research agenda for future work. Apart from this possible, alternative consideration, the policy implication arising from the observation of our result would go in the sense of enforcing investment (and free trade) due to – as we have already said – their capacity to transfer modern technology.

3.4.3.2. The induced-GDP technique, scale and cumulative effects.

Moving onto commenting on the technique and scale effects associated to the relationship between GDP and the level of CO_2 emissions, we can observe the following. As already anticipated when presenting the estimation model results, GDP – which in isolation represents the induced-GDP technique effect in our model – is positively correlated to CO_2 since the estimated coefficient is equal to +0.0204. Furthermore, when GDP is squared – this representing the induced-GDP scale effect in our model – another positive correlation with CO_2 of about +0.0054 is observed. Finally, as a result of the algebraic sum between the induced-GDP technique and scale effects the cumulative effect (which actually computed at the sample mean of GDP is equal to +0.1176) is represented by + 0.0204 + 0.0054 *LnGDP* confirms the detrimental impact generated by FDI on CO_2.

The graph here below (graph 3.21) helps to observe better the dynamic of the investigated relationship since it shows how technique, scale and effects achieved in our empirical analysis impact on the level of CO_2 emissions from the sectoral fuel combustion.

Graph 3.21



We can more clearly observe how in a first phase, the impact of the GDP growth on the environment is detrimental. As a result, we would be unable to accept the validity of those considerations which typically refer to the technique effect as a driver of environmental quality improvement due to technological innovation and diffusion processes, which is generally thought to be self-contained in the wealth increase. When GDP further increases, that is when the scale effect is taken into consideration and reaches a turning point we compute at a level of GDP per-worker in the sector equal to 2.28E-02[93], its impact on CO_2 still remains detrimental although characterized by a minor magnitude.

Together these two results do not allow us to argue in favour of that vein of literature which supports the existence of an inverted-U relationship, namely the Environmental Kuznet's Curve (EKC). Our evidence confirms what is reported in those works where authors, working with different sets of pollutants while adopting various techniques of econometric analysis to investigate the relationship between GDP (income level) and the pollutant agent considered time by time, find themselves unable to identify or to fully confirm the existence of the EKC (i.e. Stern, 2004[a]; 2004[b]; Perman & Stern, 2003; Yandle et Al., 2002). A more recent work specifically focusing on the same OECD area subject of our analysis over the period between 1960 and 2003, and employing a semi-parametric method of generalized additive models to enable the use of more flexible functional forms, has not found any useful relationship between economic growth (that is GDP increases) and CO_2 reduction.

In more detail, the authors of this work divide the model into technique, scale and composition effects and find that the technique effect is not enough to reduce CO_2 emissions (and energy use as a broader investigated proxy) except for high-income countries (Tsurumi & Managi, 2010). To remain within the OECD context and, more specifically, in relation to Canada, further analysis employing semi-parametric and flexible nonlinear parametric modelling methods in an attempt to provide more robust inferences finds very little evidence (however not

[93] The turning point is here computed by considering the partial derivative with respect to GDP of our estimated function ($LnCO_2 = 0.0204\ LnGDP + 0.0027\ LnGDP^2$) and then making it equal to zero. The result is LnGDP = -(0.0204/0.0056) = -3.78 which converted into real numbers through exp(-3.78) gives 2.28E-02.

enough to provide an adequate statistical support) to confirm the validity of the existence of the EKC hypothesis as the result of the relationship between GDP and CO_2 (He & Richard, 2010). As further evidence against the existence of the EKC hypothesis, Aslanidis and Iranzo (2009), by employing the use of econometric techniques for smooth transition regressions to investigate a panel data containing information on CO_2 emissions for non-OECD countries between 1971 and 1997, did not find any evidence of EKC.

In addition, another investigation, although focusing on Japan (which is an OECD partner) and China (as a non-OECD country) to investigate the relationship between economic growth and CO_2 (the analysis also separately considers SO_2 as a further pollutant) over the last 30 years, finds no evidence of EKC (Yaguchi et Al., 2007). As already said, however, other works show evidence to confirm the EKC hypothesis. For example, authors such as Mazzanti et Al. (2007) and Shafik and Bandyopadhyay (1992) work on different sets of pollutant (CO_2 among these) and show how a linear effect between economic growth and most of the pollutants they take into consideration can be proven. Another work pro the existence of the EKC investigates the case of France while methodologically taking into account, as an estimation method, the autoregressive distributed lag (ARDL) approach to cointegration and finds significant evidence of the existence of a relationship between GDP and CO_2 in the sense of the EKC (Iwata et Al., 2010). Some other studies find evidence to support that both the existence and inexistence of the relationship implied by the EKC hypothesis depend on what the analyses are based on. More precisely, this depends on the geographical scale (whether local or global) at which a considered pollutant is taken into consideration (e.g. Lieb, 2003).

All this apart, however, if we look at the quantitative aspect of the coefficients achieved from our empirical analysis and observe the very little numbers characterizing the impact of GDP on CO_2, we would feel induced to argue in terms of an almost neutral role of growth on the environmental feature we are considering in this analysis and reconsider some aspects of what has been said above. In fact, the very small impact of GDP on our considered pollutant cannot find any other explanation apart from the fact that growth is considered as a carrier of technological innovation and diffusion through which a more effective and efficient use of the natural resources can be guaranteed. Furthermore, although our discussion cannot exactly be developed in terms of the EKC argument for the reasons we have already said, what our result makes us observe is that, anyway, an increase in the scale of the economy reduces the magnitude of the negative impact on CO_2, which already appears to be quantitatively very low.

The policy indication arising from these considerations would suggest us to go along with what is generally prescribed by the EKC hypothesis - although our analysis does not enable us to validate it - which states that becoming richer can represent a solution to environmental degradation in the sense that country or population richness per sé can be seen as a driver for pollution abatement.

3.4.3.3. The impact of FDI on CO_2 through GDP.

Similarly to what has been done before, in this section we aim to develop a brief discussion on how our considered pollutant is affected by the sectoral inflow of FDI through GDP in consideration of the fact that in the real world the latter contains components of the earlier and is then also influenced by it. To this end, for the reasons already referred in the previous sections, we consider our data in first-differences and estimate OLS, FE and RE for the following log-log functional form[94]:

$$GDPsctr_{it} = \alpha + \beta_1\, FDIsctr_{it} + \beta_2\, FDIsctr^2_{it} + \beta_3\, GCF_{it} + \beta_4\, SCTRrel_{it} + \beta_5\, MKTopn_{it} + \beta_6\, PROTarea_{it} + \beta_7\, EDU_{it} + \beta_8\, CRpr_{it} + \varepsilon_{it}$$

where: *i* and *t* (1981-2005) represent the cross-sectional and temporal units in our panel respectively; *GDPsctr* is the gross-domestic product normalized in per-capita terms; *FDI* and *FDI²* are the linear and quadratic forms of the sectoral inflow of FDI per-unit of GCF (Gross Capital Formation); *SCTRrel* represents the sectoral relevance; *MKTopn* represents the market openness of our considered

[94] As has already been done in the previous sections, we consider our functional forms in log-log terms with the aim of achieving results representing the elasticities of the investigated relationships. In addition, the log-log form is an appropriate transformation when dealing with numerical values which are not homogenously measured.

economies; *PROTarea* is the surface of protected area; *EDU* represents the education levels; *CRpr* is the cross-product already described in the table of the summary of the statistics; ε is the error term[95].

The estimation results are presented in the table below (tab. 3.18) and are produced on the basis of robust standard errors achieved through the same estimation strategy used for the previous analyses[96].

Tab. 3.18 – Panel data estimation results.

GDP dep. var.	OLS	FE	RE
FDIsctr	-.0003** (.0001621)	-.0004** (.0002113)	-.0003 (.0003311)
FDIsctr^2	-.0005* (.000163)	-.0001 (.0001084)	-.0003** (.0001216)
GCF	.5906*** (.0748467)	.5740*** (.059718)	.5818*** (.0555791)
SCTRrel	.9255*** (.0420819)	.9217*** (.037728)	.9244*** (.0266163)
MKTopn	-.9355*** (.031253)	-.9371*** (.0283951)	-.9353*** (.0133234)
PROTarea	-.1023 (.0629324)	-.0908 (.0598551)	-.1010 (.062996)
EDU	.5613 (.4668636)	.6867 (.4415629)	.5817** (.2496277)
CRpr	-.0006** (.0002854)	-.0005** (.0002339)	-.0006 (.0003542)
Constant	.03111 (.0201189)	.0309* (.0172098)	.0323*** (.005824)
N. obs.	**292**	**292**	**292**
N. groups	**27**	**27**	**27**
R-squared	**0.9494**	**n.a. with robust estimates**	**Rho = .0298**
Adj. R-squared	**n.a. with robust estimates**		

Robust standard errors in parenthesis; P-value: * ≤ 1%, ** ≤ 5%; * ≤ 10%**

The Brush-Pagan test, computed for the choice between OLS and FE/RE models, generates a chibar2 = 0.52 and a p-value of 0.2351 which make us choose the OLS over the FE/RE.

[95] The variables considered for this estimation task are the same as those used for the analysis of model [3] except for GDP (which was considered in per-worker terms and now is in per-capita terms) and for FDI and FDI^2 (which were both normalized per-GDP and now are considered in per-GCF terms).

[96] As already reported in footnote 59, in particular OLS and FE are estimated through the use of *xtscc* Stata program which allows the computation of standard errors robust to forms of spatial and temporal dependence (Hoechle, 2007).

Tab. 3.19 – The Brush-Pagan (LM) test results.

	Var	Sd = sqrt(Var)
GDP	.1237556	.3517891
E	.0058308	.0763597
U	.0001792	.0133868
Test: Var(u) = 0	**Chibar2(1)** = 0.52	**Prob** > **chi2** = 0.2351

To the purpose of our present discussion, which is the identification of how FDI impacts on CO_2 through GDP in the sector under consideration, we limit our observation to only those results characterizing the GDP-FDI relationship and no comment is given in relation to the other evidence we have obtained. In fact, as has been done in previous sections, the answer to the question now subject of our analysis can be given by referring back to the estimation result we have obtained for model [3], which in a short form can be written as

$$CO_2 = 0.0204\ GDP + 0.0027\ GDP^2 + 0.0058\ FDI + 0.0007\ FDI^2 + ...$$

from which we take the partial derivatives of $\partial CO_2 / \partial FDI$ and $\partial CO_2 / \partial GDP$ and the result of the estimation just produced

$$GDP = -0.0003\ FDI - 0.0005\ FDI^2 + ...$$

from which we take the partial derivative of $\partial GDP / \partial FDI$. By computing $[(\partial CO_2 / \partial FDI) + (\partial CO_2 / \partial GDP)] \times (\partial GDP / \partial FDI)$ with FDI and GDP considered as their sample mean value (FDI = -0.4723 and GDP = 18.0072 as reported in the table of the summary of the statistics) we get a result equal to +0.00002. This result would represent, on average, the actual impact FDI exerts on CO_2 through GDP. Its positive sign basically confirms what has been said in the previous section where the induced-FDI and the induced-GDP effects on the considered pollutant were examined. Apart from the algebraic sign, however, what should be highlighted is the very low number characterizing it. This would induce us to confirm the almost neutral role FDI plays to the detriment of the environment, this intended in terms of CO_2 emissions from sectoral fuel combustion.

3.4.3.4. The composition effect.

The composition effect is considered in the present analysis in two ways. The first refers to a broader concept of the composition of an economy and is observed in terms of the capital-labour ratio (actually measured by the ratio between the Gross Capital Formation - GCF - and the total number of workforce) in the entire economy of our considered countries. The second, more specifically, refers to the relevance of the manufacturing sector in the whole economy (actually measured by the ratio between the sectoral GDP and the total GDP).

With regard to the relationship between the computed measure of GCF and the considered type of CO_2, our analysis has shown a positive correlation which could be interpreted by saying that the more the capitalization level of the considered economies increases, the more the detrimental impact on CO_2. Our evidence agrees with what has been found in those works, where the increase and accumulation of fixed assets (plants and machinery, vehicles, buildings, etc.) has been found to result in higher production levels, more consumption and more pollution as a result. Various authors have proven the existence of a positive correlation between emission intensity and capital intensity while considering different pollutants (e.g. Mazzanti et Al., 2007; He, 2006; Cole & Elliott, 2005; 2003; Antweiler et Al., 2001). Although dealing with the trade issue, for example, Antweiler et Al. (2001) postulate a Factor Endowment Hypothesis (FEH) and investigate the environmental impact deriving from trade liberalization. By using a panel data on city-level ambient SO_2 concentration, they find evidence that a 1% growth in the capital-labour ratio of a country generates a 1% increase of SO_2. In their view, the FEH predicts that liberalization of trade leads to a rise of polluting emissions in those countries characterized by capital abundance. Vice-versa for those countries characterized by capital scarcity. In replicating this study, Cole and Elliot (2003) extend the analysis to take into consideration other pollutants such as CO_2, NO_X and Biological Oxygen Demand (BOD). They also find statistically significant positive correlations, which confirm that the higher the capital to labour ratio is, the higher the pollution intensity is.

This type of evidence could seem counterintuitive with respect to the generally accepted perception that capital accumulation brings technological advances from which beneficial effects on the environment are generated. Although this cannot be denied, we have to consider how it cannot always be considered as the rule of thumb. Technological progress can certainly play a role in abating pollution, but it might also be unable to contribute to the solution of the problem of pollution if capital accumulation proceeds at a faster pace than the actual implementation of technological advances. The policy implication associated to what has just been discussed can rely on the recognition that capital accumulation (which broadly means the production of public and private goods and services) may be realized in various ways, including those which could be detrimental to the environment. This also implies the recognition of the existence of externalities, whose solution can be somehow found in the policy approach which calls for the implementation of environmental taxation, although – as we are generally aware – monetizing environmental values is not easy – and, in fact, is sometimes impossible – to do. All this could become food for thought on what type of taxation policy could help to rise capital formation holding the feature of being environmentally sustainable (selective business tax-incentive, personal tax cuts, etc.).

With regard to the other version of the composition effect in our model, considered in terms of relevance of the "manufacturing" sector in the whole economy, the estimation results we have achieved show a negative relationship with CO_2. This would highlight the beneficial role the manufacturing sector plays in reducing CO_2 emission which, according to a generally accepted view, is explained through the fact that free trade and investment promote comparative advantages among nations inducing them towards an efficient specialization of their economic systems (OECD, 2001).

In other words, our result would induce us to say that the "manufacturing" sector we have analyzed is characterized by comparative advantages, making our considered countries' economies cleaner (in terms of CO_2) the more specialized they are in it. More specifically, specialization is due to the sectoral efficiency in resource allocation which makes production achievable by employing lower inputs per unit of output and less polluting as a result. This finding agrees with that part of the literature which refers to the existence of a beneficial result of the composition effects (or structural effect) on the environment, although the opposite situation is also thought to be true. As has been highlighted by some authors (e.g. Cole & Elliott, 2003), the actual impact of the composition effect on the environment depends on a given country's comparative advantages, which could lead to different types of economic specialization and to diverse forms of environmental impact (either positive or negative) as a result. To clarify this, it must be considered that trade and investment liberalization unavoidably change the production-mix of a country towards those products where it has a comparative advantage. This implies the implementation of a resources reallocation process within the considered country through which trade and investments improve their economic efficiency. However, the environmental effect will exclusively depend on the type of sectors in which the country builds its comparative advantage. If the expanding sectors are less energy intensive than the contracting ones then beneficial results will be observed on the environment and vice versa. In other words, the composition effect will result in less polluting emissions.

The orientation of policy, which could be considered in association with this finding, is not different from that sketched above where the correct pricing of environmental assets and externalities - which can even occur through the implementation of taxation mechanisms - might be relevantly important to ensure efficiency and orient investment and trade while avoiding their shift towards environmentally-damaging sectors (OECD, 2001).

3.4.3.5. Other evidence.

As already said in presenting the analysis results, the variables represented by the surface of the protected area, the education level and the cross-product are not found statistically significant and, therefore, no comment can be made on their policy implications.

The only noteworthy result for this last section is represented by the market openness variable which is found significant and positively correlated to CO_2. It highlights that those countries characterized by higher degrees of trade openness are also those impacting more on our considered environmental variable. The evidence we have achieved agrees with what is reported by some studies, which have found positive correlations while investigating the relationship between pollution and market openness with reference to different developing and developed countries (e.g. Feridun et Al., 2006; Hill & Magnani, 2002). However, it is against the results produced by other studies - all belonging to the mainstream thinking - which observe the existence of a virtuous relationship between trade, investment and environmental pollution (e.g. Ghosh, 2007; OECD, 2002[b]). These studies base their explanations on the fact that where trade – and investment, as a result of the strong correlation proven in various studies – is freer, a decrease in environmental pollution is the consequent outcome. This is believed to be a natural consequence of the globalization process and the specialization of economies, whose expected results are of major efficiency in the allocation of the level of resources and of minor environmental impact (OECD, 2002[b]; Lucas et Al., 1992).

Apart from this, considering that trade and investment can be seen as the two faces of the same coin, we would be induced to interpret the result we have achieved as a confirmation of the previous one obtained for the relationship between the FDI inflow and CO_2 emissions. Although this is partially true, it must be pointed out that the two results should be read separately since one (the relationship between the FDI inflow and CO_2) is associated to a sectoral dynamic. The other (the relationship between the level of market openness and CO_2) considers the broader picture given by the total figures of import and export and does not specifically represent any sectoral dynamics, although it must be considered that the manufacturing sector now under consideration represents one of its composing aspects.

The policy implication deriving from our observation could focus on the opportunity that trade and investment agreements should hold stricter provisions, especially with regard to those sectors of activity generating CH_4 emission, to avoid environmental degradation while, at the same time, guaranteeing that free trade and investment can take place.

3.5. The analysis of the "transport and communication" sector.

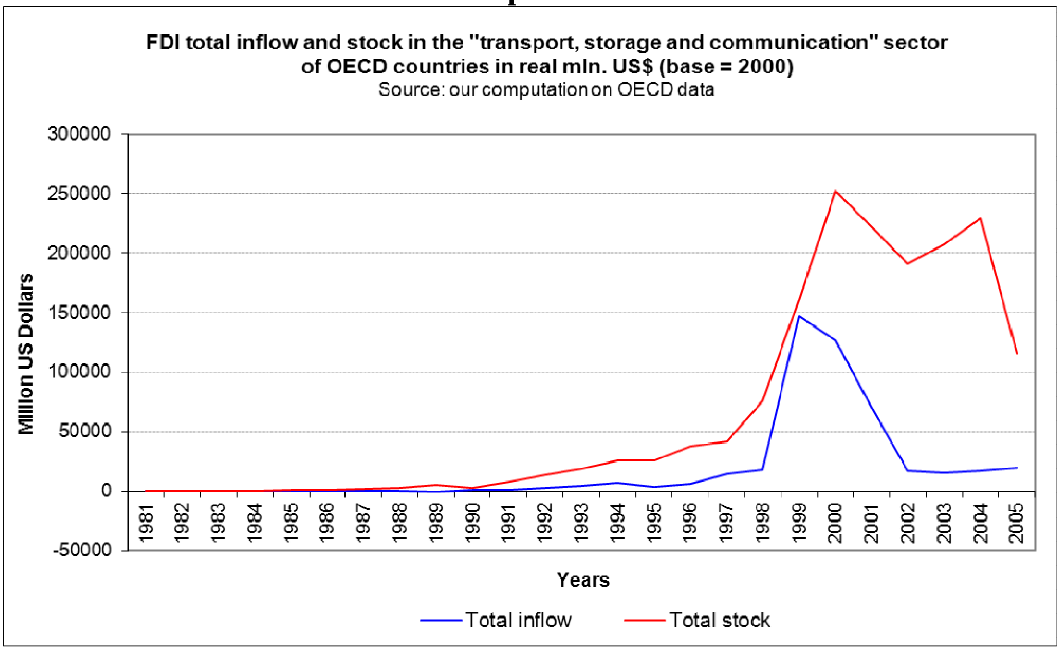
In briefly presenting this sector we observe the magnitude of its contribution to the total GDP in the OECD area subject of our consideration. Some computations based on UN data show how in 1981 this sector contributed about 12.04% to the total GDP formation. This percentage grew slightly to 12.49% in 1993 to become about 13.5% in 2005.

With the aim of building an adequate preamble to the issues in this section, we first proceed by analysing the FDI inflow and stock (or inward position) in the considered sector between 1981 and 2005. Furthermore, we explain the reasons for the choice of CO_2 from the sectoral fuel combustion as our considered environmental variable and analyze its trends over the investigated period.

With regard to the analysis of the sectoral FDI trends, the graph below (3.22), which is built on the year by year aggregation of the data of FDI inflow and stock in the “transport, storage and communication” sector of the considered 30 OECD countries (see table III.8 and table III.9 in the appendix section), shows that between 1981 and 2005 the sectoral inflow of FDI increased – although with significant fluctuations – from about 26 million US$ in 1981 to about 19,482 million US$ in 2005. The breakdown by country, instead, enables us to observe how, during the considered period, the major receiving countries were the U.S.A. (with about 173,892 million US$) and the United Kingdom (with about 98,908 million US$). These are followed by Japan (with about 27,936 million US$), Germany (with about 26,030 million US$) and Spain (with about 20,300 million US$). Apart from Canada, Luxembourg and New Zealand (for which no data are reported) and Ireland (for which a disinvestment of about -44 million US$ is recorded), the countries which received minor investment are: Iceland (with about 27.59 million US$) the Slovak Republic (with about 1,027 million US$) and Portugal (with about 2,528 million US$).

With regard to the sectoral FDI stock, a general rise can also be observed. In the considered OECD area the stock – although with fluctuations – moved from about 58 million US$ in 1981 to 115,714 million US$ in 2005. Here again, the breakdown by country shows how the U.S.A. (with about 557,853 million US$) and the United Kingdom (with about 371,356 million US$) are those countries which capitalized the major investment stock quota. With the exception of Belgium, Ireland, Luxembourg, New Zealand, Spain and Sweden, for which no investment stock records are reported, a minor quota of investment stock can be observed for Iceland (with about 413 million US$), the Slovak Republic (with about 2,315 million US$) and Portugal (with 7,498 million US$).

Graph 3.22

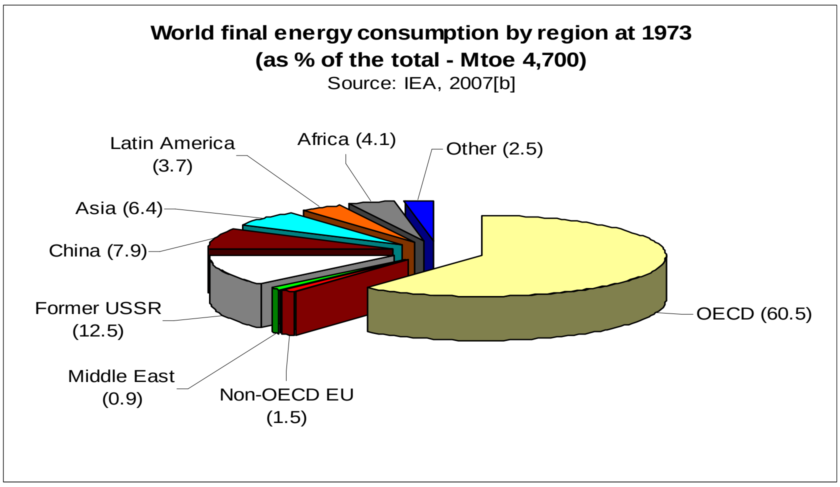


Moving now onto explaining the reason for the choice of the considered pollutant, we can simply say that CO_2 - as stated in other parts of this work - is one of the five GHGs contributing to global warming and is the result of a natural phenomenon as well as the consequence of anthropogenic activities, especially those associated to the consumption of energy. Transport and its linked activities rely heavily on the use of energy and, particularly, on fossil fuels.

To make reading of this section easier, we propose again and very briefly a part of the analysis already developed in the previous section with regard to the world energy consumption by region, and the OECD energy consumption by product and by sector.

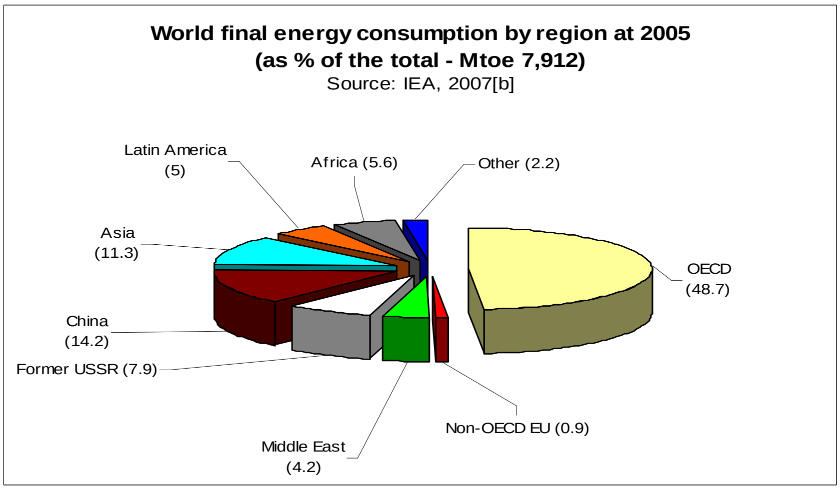
The analysis of the energy consumption data shows how the OECD area plays a primary role in the world scenario. Due to the lack of a complete time series, which would have allowed us to analyse the full period subject of our investigation (1981-2005), we focus on two specifically considered periods, namely 1973 and 2005. They help us to understand how the trend of energy consumption has evolved over the decades up to 2005 (IEA, 2007[c]). As graph 3.23 shows, in 1973 the OECD countries were already the main consumers of energy worldwide. In fact, they consumed 60.5% of the worldwide final energy consumption this being equal to 4,700 Mtoe. OECD countries were followed by the former USSR and China with 12.5% and 7.9% of the final energy consumption respectively[97]. A similar situation can be observed with regard to 2005 (graph 3.24) when the OECD countries were confirmed to be the main energy consumers worldwide with their consumption level being 48.7% of the total world final energy consumption equal to 7,912 Mtoe. They were primarily followed by China (14.2%) and the rest of the Asian countries (11.3%).

Graph 3.23



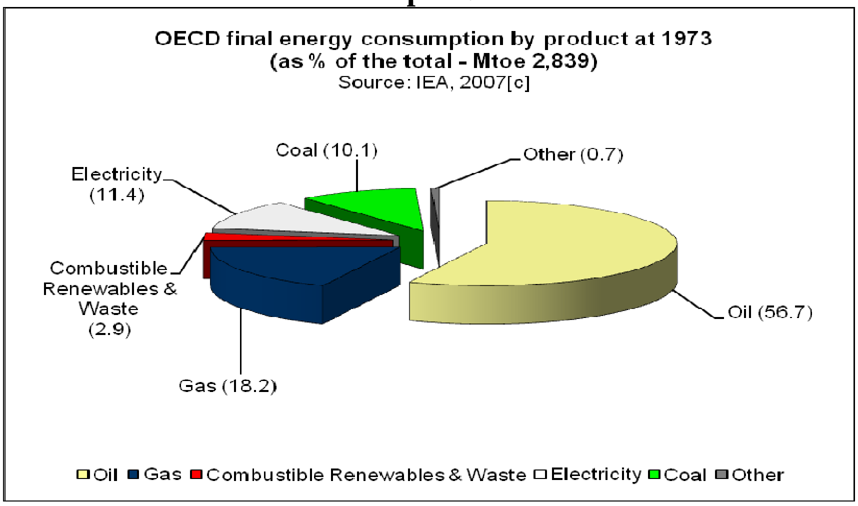
[97] According to IEA (2007[b]:30), under the label "other" in graphs 3.23 and 3.24 we classify world marine bunkers.

Graph 3.24



Following the same observation method (at 1973 and 2005) and moving onto scrutinizing the data associated to the type of products from which the energy consumption of the OECD countries derives, we can learn how fossil fuels (particularly oil) represent the primary energy vectors (IEA, 2007[c]). The following graph (3.25) shows how in 1973 fossil fuels were the major energy vector representing 66.8% of the total final energy consumption equal to 2,839 Mtoe. More specifically, 56.7% of the final energy consumption was generated by the use of oil and 10.1% from coal[98].

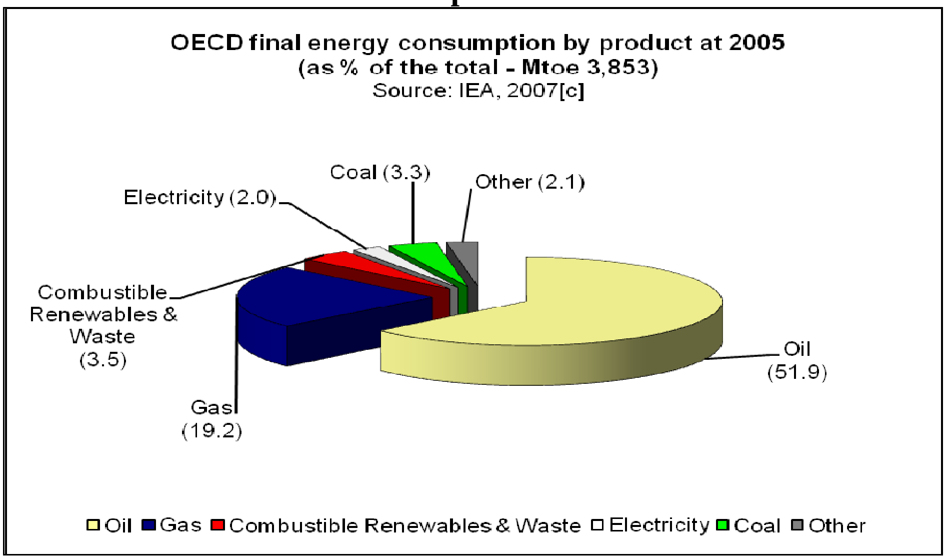
Graph 3.25



[98] In graphs 3.25 and 3.26 the label "other" is mainly for geothermal, solar, wind and heat energy vectors (IEA, 2007[c]: 29).

The situation at 2005, represented in graph 3.26, was characterized by an energy consumption which, although lower, was still particularly associated to the use of fossil fuels. About 55.2% of the total energy consumption (equal to 3,853 Mote) was guaranteed through the use of fossil fuels. More precisely, 51.9% from oil and 3.3% from coal (IEA, 2007[c]).

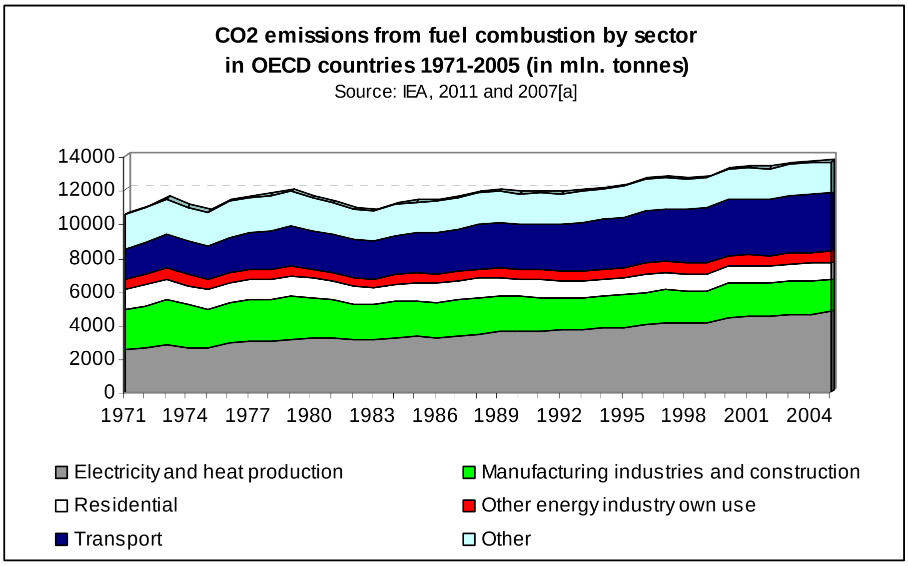
Graph 3.26



With specific regard to the aspect of CO_2 emissions from fuel combustion, we can observe how the OECD area represents a relevant contributor to their generation at global level. Some computations made by using IEA data – part of which are synthesized in a publication of IEA (2011) – shows us that between 1971 and 2005 the level of CO_2 from fuel combustion in the OECD area was on average equal to 56.5% of the world total.

As has been anticipated, the transport sector is among those largely responsible for this type of emission. It is generally known that transport severely depends on the use of energy produced from fuel combustion, from which CO_2 emission is particularly generated. Worldwide transport fuel use has always and is still lead by petroleum. About 95% of fuel used is represented by either gasoline or distillate fuels such as diesel, kerosene, or jet fuels. As a result, it is possible to observe how at a global level the transport sector accounts for about one quarter of energy related CO_2 emissions (IEA, 2009[b]). From some computations based on the statistical information dispatched by the IEA database and with specific regard to the time span we consider in our analysis, it is possible to learn how the worldwide contribution of transport to the total generation of CO_2 from fuel combustion moved from about 20.5% in 1981 to about 23.4% in 2005. At OECD level, as shown in graph 3.27 below – which reveals the contribution of some considered sectors to the generation of CO_2 from fuel combustion between 1971 and 2005 – it is possible to observe how, apart from the general increase of the emission levels, "transport" is confirmed to be among the main anthropogenic contributors (more precisely, the second major contributor) together with "electricity and heat generation" and "manufacturing industries". More specifically, between 1971 and 2005, the "transport" sector" emitted an average quantity of 2,659.8 Mtoe of CO_2 per year, this being – always in terms of average – about 60.6% of CO_2 emissions from fuel combustion generated at world level in the same considered sector (IEA, 2011; 2007[a])[99].

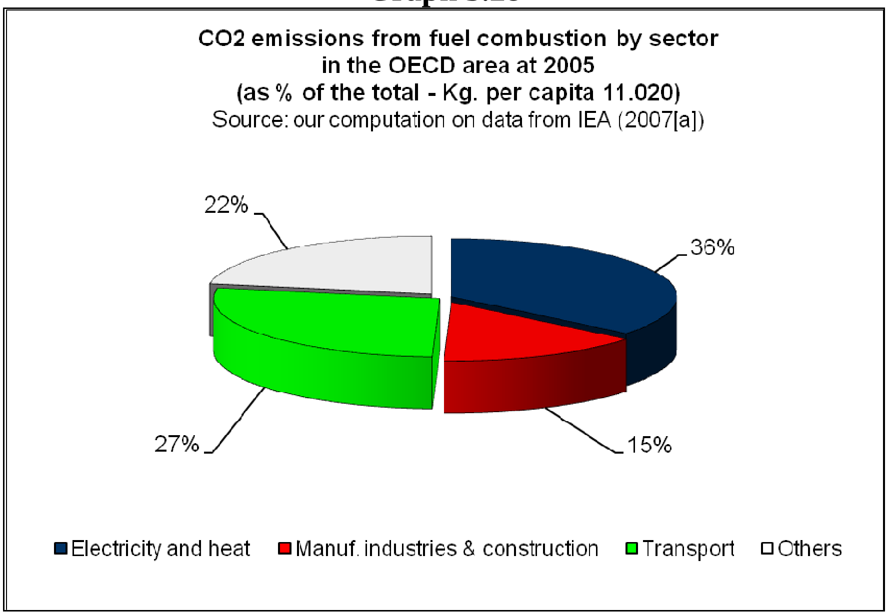
Graph 3.27



[99] In the same considered period the "electricity and heat generation" sector emitted, on average, about 3,517.26 Mtoe per year, that is 57.9% of the total world emission associated to the sector in question. The "manufacturing and construction" sector generated, on average, 2,146.3 Mtoe per year, which corresponds to about 47.9% of the world sectoral figure. The sector generically labelled as "other", which includes among its main voices "commercial and public services", "agriculture and forestry", "fishing", "other energy industries" and "other emissions not specified elsewhere", generated, on average, about 1,903.18 Mtoe per year, this representing about 59.9% of the world total emissions of the considered pollutant in the same considered sectors. The "residential" sector emitted an average of about 1,090 Mtoe per year, corresponding to about 64.3% of the sectoral world emission. The sector identified as "other energy industry", instead, generated about 605.9 Mtoe as a yearly average, this corresponding to an average of 59.6% of the sectoral world emission (IEA, 2011; 2007[a]).

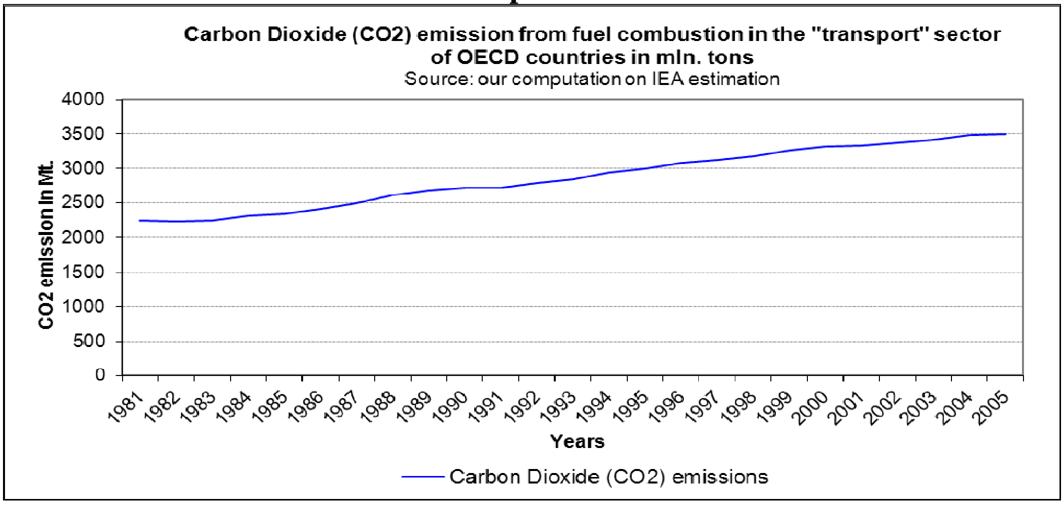
A snapshot at the records associated to the last year considered in our analysis – namely 2005 – makes us realize the relevance of the transport sector in the generation of CO_2 emissions from fuel combustion. As graph 3.28 below shows, in the whole OECD area, transport – which is the sector subject of investigation in this work – contributes 27% to the generation of CO_2 emission from fuel combustion. It is preceded by the "electricity and heat" productive sector, which contributes 36%. It is followed by the "industrial manufacturing" sector, whose contribution is 15% of the total considered emission and by the generic "other" sector (with its 22%), which must be intended in the same way as mentioned in the previous footnote (IEA, 2009[a]; 2007[a]).

Graph 3.28



Before concluding this section, a final look is given to the trend of CO_2 from fuel combustion in the transport sector of OECD countries between 1981 and 2005. As can be seen below in graph 3.29 – which is built on the year by year aggregation of the IEA data associated to the OECD countries we are considering in this study (see table III.10 in the appendix section) – the pollution of CO_2 from fuel combustion related to transport activities increased over the considered period moving from a total of 2,249.78 million tons in 1981 to 2,851.87 in 1993 to 3,495.28 in 2005. The breakdown by country – built on the cumulative emissions over the period 1981-2005 – shows how the U.S.A. (with 37,435.46 million tons), Japan (with 5,392.03 million tons), Germany (with 3,874.02 million tons), Canada (with 3,308.85 million tons), France (with 2,882.32 million tons), the United Kingdom (with 2,851.01 million tons) and Italy (2,482.09 million tons) are the most polluting. Iceland (with 14.87 million tons), Luxembourg (with 83.08 million tons) and Slovak Republic (with 102.42 million tons) are those generating a minor level of CO_2 emissions from fuel combustion[100].

Graph 3.29



According to a preeminent analysis, this increase in the considered emission levels is explained by the fact that OECD countries have always been and still are the main drivers of petroleum products in the transport sector. This is the result of the transport modes characterizing our considered area. Firstly, the passenger transport demand – which is influenced by household revenues, commuting distance and the distance between home and school – has heavily relied on road transport for the last decades[101]. This is also the result of the fact that the increase in GDP, together with considerable advances in infrastructure and technology, has

[100] If we stop our data observation at the last year considered in our analysis (2005) and normalize it on the basis of the countries' population, it is noteworthy how the five most polluting countries are Luxembourg (with about 1.82E-04 million tons per capita), the United States (with about 1.25E-04 million tons per capita), Canada (with about 1.02E-04 million tons per capita), Australia (with about 7.91E-05 million tons per capita), and New Zealand (with 6.03E-05 million per capita).

[101] To give just an example, in the three key OECD regions (U.S.A., Europe-15 and Japan) road transport represents about 96% of the 13,760 billion passengers per kilometre travelled in 2000 (Plouchart, 2004).

generated an increase in motor vehicle ownership. Secondly, freight transport – which is basically influenced by GDP and world trade – follows and drives the dynamic of the globalization phenomenon. In the last two decades freight transport has increased at a very fast pace because world trade has expanded (+170%) and GDP increased (+50%). As a result, over the same considered period the road and air transport segments have significantly grown (+120%) worldwide (Plouchart, 2004)[102]. In addition, it can be said that the trend of CO_2 emissions from fuel combustion is destined to further increase at both global and OECD levels. According to some IEA projections, the fuel demand from the transport sector will grow worldwide by about 40% by 2035 (IEA, 2010; 2011).

Having introduced the main issues subject of argument, and elucidated the link between the transport sector and the pollutant (CO_2 from fuel combustion) we have chosen for our investigation, we can proceed in developing this section according to the previous two sections. Therefore, the next two subsections will be respectively devoted to the model description and the analysis of the results. A further subsection will be dedicated to the conclusive discussion and the identification of some possible policy implications.

3.5.1. The modelling strategy description.

The investigation of the relationship between the inflow of FDI in the "transport, storage and communication" sector of OECD countries and their environmental quality (namely, CO_2 from the sectoral fuel combustion) is based on the use of a previously composed unbalanced panel dataset. The composition of the dataset is characterized by substantial country disparities, which should ensure a good efficiency level in the empirical analysis. It contains 24 variables - which have all been tried in the numerous estimation attempts - and focuses on statistics from the 30 OECD countries already mentioned for the period between1 1981 and 2005. In the table below (3.20), only those variables which have

[102] For example, domestic commerce consistently relies on road transport in the three key OECD areas (U.S.A., Europe-15 and Japan), this representing 36% of the total amount of tonnes per kilometre moved in 2000 (Plouchart, 2004).

performed for the identification of the best fit model are reported together with their source.

Tab. 3.20 – Variable specification for model [4][103]

No.	Variable	Description	Source
1	CO_2sctr	Dependent variable. Natural log. of the ratio between the amount of carbon dioxide (in million tons) from fuel combustion in the sector and the country area (in squared km.).	Our computation on IEA estimation and UN data
2	GDPsctr	Natural log. One year lag of the ratio between the sectoral GDP (in real US$) and the amount of population.	Our computation on UN/OECD data
3	GDPsctr^2	(GDPsctr * GDPsctr); square of the natural log. of the sectoral GDP per capita (in real US$).	Our computation on UN/OECD data
4	FDIsctr	Four-year lag of the natural log. of the ratio between the FDI inflow in the "transport, storage and communication" sector (in real mln. of US$) and the country area (in squared km.)[104].	Our computation on UN/OECD data
5	FDIsctr^2	Square of the natural log (FDIsctr * FDIsctr) of the sectoral FDI inflow per squared km. (in real mln. of US$).	Our computation on UN/OECD data
6	GCF	Natural log. of the ratio between the amount of Gross Capital Formation (in real US$) and the total no. of work force (in thousands).	Our computation on WB, ILO
7	SCTRrel	Natural log. of a sectoral relevance indicator given by the ratio between the sectoral GDP (in real US$) and the total GDP (in real US$).	Our computation on UN data
8	MKTopn	Natural log. of a market openness indicator given by the ratio between the sum of the export and the import (taken in absolute terms) both considered f.o.b. (in real US$) over total GDP (in real US$).	Our computation on IMF/UN data
9	PROTarea	Natural log. of the surface of protected area (in squared Km.).	Our computation on UN data
10	EDU	Natural log. of the average year of school indicator.	Our computation on CID Harvard data
11	CRpr	Natural log. of the cross-product derived from the amount of GCF (in real US$) times the total FDI inflow (in real mln. US$).	Our computation on WB/OECD data

With regard to the definition of the relationship subject of our empirical investigation, we specify that it takes a log-log form and is based on variables

[103] As in the previous two sections, all the financial data was in US$ and was transformed from current to real terms by using the USA Gross National expenditure Deflator (base year = 2000) gathered from the World Bank database available online at http://databank.worldbank.org
[104] According to what is done in other works, we make the flow and not the stock of FDI the subject of our empirical task. As already mentioned, the measure of FDI stock is unsatisfactory. In fact, it represents the direct investment position on a historical-cost basis, namely the investment amount already in the host country as opposed to the flow of capital into the host country at a considered year. As already highlighted by Cantwell and Bellack (1998), the use of the book value (which is the historical cost) does not take into account the distribution of the stock age, which makes international comparison of FDI stocks almost impossible.

considered in first-differences for the reasons already said in the previous analyses[105]. In more formal terms, it is expressed as follows:

[4] $CO_2sctr_{it} = \alpha + \beta_1\, GDPsctr_{it} + \beta_2\, GDPsctr2_{it} + \beta_3\, FDIsctr_{it} + \beta_4\, FDIsctr2_{it} + \beta_5\, GCF_{it} + \beta_5\, SCTRrel_{it} + \beta_6\, MKTopn_{it} + \beta_7\, PROTarea_{it} + \beta_8\, EDU + \beta_9\, CRpr_{it} + \varepsilon_{it}$

where: ***i*** represents the cross-sectional units related to our 30 OECD countries; ***t*** is the time units from 1981 to 2005 we are considering in our analysis; ***ε*** is the error term. Having already described in table 3.20 the variables considered in the model, we now highlight that - as done in the previous sections - this model is built with the aim of identifying the direct and indirect effects of the investment flow on the considered CO_2 variable. The latter, in particular, can be observed by splitting the FDI-CO_2 relationship into technique, scale and composition effects. We do not enter into much detail of their definition, since this is abundantly done in the previous pages of this chapter together with an examination of the relevant literature (e.g. Liang, 2006; Cole & Elliott, 2003; Antweiler et Al., 2001).

What should be highlighted is that the above model takes into consideration two types of technique and scale effects: one is what we have described as induced-GDP technique and scale effects[106], the other is induced-FDI technique and scale effects[107]. We are already aware of the fact that the induced-GDP

[105] As done in the previous analyses, we decide to adopt a dynamic specification of our model and use our variables in first-differences as a result of the Engle-Granger test for cointegration we have run on the OLS model with variables considered in levels (Engle & Granger, 1987). The p-value associated to lagged value of the residuals $\hat{e}$ is equal to 0.077 which makes us accept the null hypothesis of no-cointegration, this meaning that the residuals of the regression are non-stationary and its variables are not cointegrated.

[106] As already noted, other works use two different variables to separately measure scale and technique effects. While the earlier is measured in terms of GDP per squared km., the per-capita GDP is used for the latter (i.e. Antweiler et al., 2001). In complete agreement with Cole and Elliott (2003) and differently from what done in the previous two sections (where the GDP per worker was used), this time we use the GDP per capita to capture the technique and scale effects. Other versions of the GDP variable (such as the GDP per squared km.) did not result significant. In this analysis, we also agree with the consideration by Cole and Elliott (2003) that in the real world the scale effect is likely to be contemporaneous whilst the technique effect is likely to be the result of a past income dynamic (which would suggest diversifying the variables by using lagged forms). In fact, we find the coefficient of the induced-GDP technique effect significant when considering the GDP variables at time *t-1*. The coefficient of the induced-GDP scale effect is found significant at time *t*.

[107] A similar consideration to that in the previous footnote can be made for the induced-FDI technique and scale effects. We find the coefficient of the FDI variable in isolation significant

technique, scale and their cumulative effects are achieved by deriving with respect to GDP what is reported as β_1 *GDPsctr* + β_2 *GDPsctr*^{2} in the above equation [4] (Menagi et Al., 2008; Liang, 2006; Cole & Elliott, 2003; Antweiler et Al., 2001). Similarly, the induced-FDI technique, scale and cumulative effects are achieved while considering the partial derivative of β_3 *FDIsctr* + β_4 *FDIsctr*^{2} in equation [4] with respect to FDI.

The composition effect is captured in our model by considering two different aspects, which refer to the relevance of the “transport” sector in the considered economies and their capitalization levels. More specifically, these two aspects are respectively considered by variables no. 7 and no. 6 in table 3.20, namely the ratio between the sectoral and total GDP and the capital-labour ratio.

A final comment to explain the use of a cross-product in our estimation makes us recall what has already been said in the previous sections, where it was clarified that we do so to produce a test with power to detect ignored nonlinearities in our model estimations (Wooldridge, 2002).

3.5.2. Results of the analysis.

The empirical estimation of the considered model was conducted by using the software package Stata/IC 12.1for Windows. The table below (tab. 3.21), summarizes the main statistics of the variables in the model.

Tab. 3.21 – Summary statistics of the variables considered in model [4]

Variable	Obs	Mean	Std. Dev.	Min	Max
Id	750	-	-	1	30
Year	750	-	-	1981	2005
CO_2sctr (dependent var.)	750	-2.155578	1.338793	-5.368698	.97601
EDU	750	2.12257	.2730594	1.029619	2.505526
GCF	725	22.60743	.6927433	20.40059	23.74382
MKTopn	662	-1.735082	3.153601	-14.79678	4.411031
SCTRrel	654	-2.662033	.2556098	-3.265332	0
GDPsctr^2	654	231.6674	107.5304	.8834065	693.0661
GDPsctr	653	14.89653	3.126614	.9398971	26.32615
CRpr	551	31.08903	10.99417	-34.93122	46.59235
PROTarea	480	-6.205169	1.807776	-9.219663	-1.6507
FDIsctr^2	284	6.907666	9.896788	.0003652	49.77739
FDIsctr	281	-.3915371	2.611227	-7.055309	5.342482

when considered with *4 lags*. The coefficient of the induced-FDI scale effect is found significant when considered at time *t*.

In accordance with what was done before, our model specification was tested for heteroskedasticity, autocorrelation and stationarity. The first check was made through a LR test which is a likelihood-ratio test for the null hypothesis of panel homoskedastic that the parameter vector of a statistical model satisfies some smooth constraints (Greene, 2007)[108]. The result is a chi2(25) = 1225.34 with p-value = 0.0000 which makes us reject the null hypothesis of homoscedasticity and confirms that our model specification suffers from heteroskedasticity. The test for autocorrelation was performed by recurring to a tool for panel data models developed by Wooldridge (2000), whose null hypothesis is associated to the inexistency of first-order autocorrelation[109]. The result shows a F (1, 22) value = 51.354 and a p-value = 0.0000. This makes us reject the null hypothesis associated to the inexistency of autocorrelation problems and confirms that our model specification suffers from autocorrelation. The test for stationarity was performed though the Fisher test by Maddala and Wu (1999) already described in the previous sections. The test was run up to three lags and only for the variables which were not considered in the previous analyses. As shown in the table below (3.22), all the new variables considered in this sectoral model now under investigation are non-stationary since their p-values are ≥ 0.05[110].

Tab. 3.22 - Fisher test for panel unit-root using an augmented Dickey-Fuller test*.

Variable	Lag -1	Lag -2	Lag -3
	chi2	*chi2*	*Chi2*
	p-value	**p-value**	**p-value**
CO_2sctr	*56.7393*	*62.9084*	*60.1026*
	0.5956	**0.3737**	**0.4720**
GDPsctr	*103.0862*	*165.2517*	*71.6428*
	0.0002	**0.0000**	**0.1075**
$GDPsctr^2$	*103.8589*	*179.7938*	*79.7091*
	0.0002	**0.0000**	**0.0309**
FDIsctr	*41.8005*	*49.7841*	*22.9025*
	0.6487	**0.1381**	**0.9557**
$FDIsctr^2$	*72.9574*	*40.4039*	*114.9483*
	0.0069	**0.4524**	**0.0000**

** chi2 in italics, p-value in bold.*

[108] As already highlighted, the technical literature refers to the LR test as an alternative to Wald testing for models fitted by maximum likelihood (Stata help).

[109] Once again we recall that this test is performed through the employment of the Stata *xtserial* command which implements a test to detect serial correlation in panel-data models as discussed by Woolridge (2002) and Drukker (2003).

[110] To run this test we use the *xtfisher* Stata program already described in footnote 56.

After these preliminary tests, we can now move onto presenting the outcomes achieved from our model estimation. In the next table (tab. 3.23), the results associated to the estimations of Ordinary Least Squares (OLS), Fixed Effects (FE) and Random Effects (RE) models are reported. They are obtained through the use of first-differences computed on our data to deal with the non-stationarity problem affecting our panel and on the basis of robust standard errors for linear panel models to ensure an opportune correction for heteroskedasticity and autocorrelation[111].

Tab. 3.23 – Panel data estimation results for model [4].

CO_2sctr Dep. var.	**OLS**	**FE**	**RE**
GDPsctr	.4104*** (.1339795)	1.1849*** (.4009695)	.4104** (.2003544)
GDPsctr^2	-.0207*** (.0069284)	-.0742** (.0265618)	-.0207* (.0126435)
FDIsctr	.0027* (.0014105)	.0025* (.0013611)	.0027** (.001226)
FDIsctr^2	.0007* (.0003998)	.0007* (.0003718)	.0007** (.0003065)
GCF	.0791** (.035921)	.0721* (.0351305)	.0791** (.0400559)
SCTRrel	-.0657 (.1196009)	-.0237 (.089924)	-.0657 (.1082297)
MKTopn	.0961*** (.0241741)	.0525** (.0193931)	.0961*** (.0336585)
PROTarea	.0073 (.0147812)	.0110 (.0158253)	.0073 (.0421032)
EDU	-.0992 (.0827943)	-.0787 (.1701673)	-.0992 (.1483648)
CRpr	3.45e-06 (.0000948)	-3.70e-06 (.0000853)	3.45e-06 (.0002514)
Constant	.0106*** (.0027211)	.0123*** (.002743)	.0106*** (.0033789)
N. obs.	**182**	**182**	**182**
N. groups	**22**	**22**	**22**
R-squared	**0.1586**	**n.a. with robust estimates**	**Rho = 0**
Adj. R-squared	**n.a. with robust estimates**		

Robust standard errors in parenthesis; P-value: * ≤ 1%, ** ≤ 5%; * ≤ 10%**

[111] According to what has been done before, in particular the OLS and FE models are generated by using the *xtscc* Stata program developed by Hoechle (2007). It allows the computation of standard errors robust to forms of spatial and temporal dependence.

Table 3.24 below reports the Brush-Pagan test (or LM test), to which we refer to the choice between OLS versus RE/FE. As we can observe, a chi2 equal to 1407.85 with a p-value = 1.0000 is generated.

Tab. 3.24 – The Brush-Pagan (LM) test results.

	Var	**sd = sqrt(Var)**
CO_2sctr	.0013664	.0369642
E	.0014133	.0375944
U	0	0
Test: Var(u) = 0	**chibar2(1)** = 0.00	**Prob** > **chi2** = 1.0000

This result induces us to choose the OLS model over the RE or FE models. As a consequence, we focus our attention and comment on its outcomes[112]. With regard to the relationships between the dependent variable and the two considered measures of GDP, we first observe a positive (+0.4104) and statistically very significant (p-value = 0.006) correlation between CO_2 and GDP taken as it is. When we go further and consider the squared measure of GDP, a negative (-0.0207) and still highly significant (p-value = 0.007) correlation with the dependent variable is observed. As has already been done in the previous sections, we comment on these two results denoting the GDP-CO_2 relationship in light of the induced-GDP technique, scale and cumulative effects.

The first estimated coefficient β_1 represents the technique effect of our relationship and has the environmental-economic meaning that a 1% increase in GDP generates a rise of about 0.41% of the sectoral CO_2 from fuel combustion. The second estimated coefficient, computed in terms of $2\beta_2$ *GDPsctr* (resulting from the partial derivative of equation [4] with respect to GDP) represents the scale effect of our relationship and is equal to about -0.0414. Its meaning is that a further increase of 1% of GDP results in a decrease of the sectoral CO_2 by about 0.04%. The identification of these two effects allows us to observe the cumulative or total effect of our considered GDP-CO_2 relationship. As we know, it is

[112] It must be noted that the estimation of this model shows a highly significant F-test for the joint significance of the variable considered with F(10, 21) = 26.99 and p-value = 0.0000. Apart from this automatically generated test, we also run a F-test to check for the joint significance of the two variables associated to GDP and the other two variables associated to FDI. The earlier test generates a p-value = 0.0412. The latter shows a chi2 = 7.01 and a p-value = 0.0354. As a result, we can reject the null hypothesis of the test that the estimated coefficients of the considered variables are jointly significantly equal to 0. Therefore, we can say that our model including these variables is correctly specified.

represented by the contemporary consideration of the two coefficients in $\beta_1 + 2\beta_2$ GDPsctr, resulting - as we have already said - from the partial derivative of equation [4] with respect to GDP. From an environmental-economic view, it means that the considered measure of CO_2 changes of *0.4104 - 0.0414 GDPsctr* when GDP increases by 1%. Furthermore, as in the previous analyses, the induced-GDP cumulative effect can actually be computed at the sample mean value of GDP (that is by substituting *GDPsctr* for the mean value of GDP as reported in the table describing the statistics) and is equal to -0.2063 as a result of the dominance of a negatively-signed scale effect over the positively-signed technique effect.

With regard to the relationship between the sectoral inflow of FDI and the considered pollutant, we find a statistically significant (p-value = 0.068) and positive (+0.0027) correlation when the FDI variable is taken as it is in isolation[113]. The achieved result, which represents the induced-FDI technique effect of the investigated relationship, allows us to say that a 1% rise of the investment flow entering the OECD countries in their “transport, storage and communication” sector would produce a growth of CO_2 from fuel combustion in the transport sector by about 0.003%. Also statistically significant (p-value = 0.100) and positive (+0.0007) is the correlation between the square of the considered FDI variable and the sectoral level of CO_2 emissions.

Once again, the interpretation of this result can be read in terms of the scale effect characterizing our relationship, whose coefficient is equal to about +0.0014 and is achieved through $2\beta_4$ *FDsctr* resulting from taking the partial derivative of equation [4] with respect to FDI. Considering the technique and scale effects together, we observe the cumulative or total effect of FDI on CO_2 we consider in the analysis. Its coefficients are represented by 0.0027 + 0.0014 *LnFDI* (resulting from the partial derivative of equation [4] with respect to FDI) and an actual value can be computed by operating algebraically and substituting *FDIsctr* for the mean of the FDI as reported in the table giving the summary of statistics. This generates

[113] It is the case to remember that in our analysis we consider the FDI variable with a four-year lag. A possible explanation of this could be seen in the fact that the effect of the considered FDI on the pollutant subject of our investigation becomes evident four years after the investment implementation.

a positive number equal to about 0.0022 (as a result of the positive signs characterizing both the technique and scale effects) which identifies a detrimental role of the investment activity on the environment although with a very small quantitative significance.

The relationship between the capitalization level (considered in terms of GCF) of the investigated OECD economies and the considered CO_2 emissions is also found to be significant (p-value = 0.039) and positive (+0.0791). Since the capitalization level variable is built to represent a first aspect of the composition effect in our model, we could comment on this result by saying that in the transport sector and its related activities the composition effect (broadly intended in terms of capital accumulation) plays a detrimental role to the environment. In fact, a 1% growth of the capitalization level would generate about a 0.08% increase of the considered type of CO_2 emissions. It must be highlighted that the second aspect of the composition effect considered in our model, associated to the variable indicating the relevance of the sector, is not found statistically significant and, for this reason, we do not make it the subject of comment.

With regard to the relationship between the variable indicating the market openness of the considered countries' economy and the dependent variable, a highly significant (p-value = 0.001) and positive (+0.0961) correlation is found. The practical implication of this result would mean that a 1% increase of the market openness level produces a rise of about 0.1% of the sectoral CO_2 emissions.

No comment can be given for the remaining variables considered in our model (namely, the surface of protected areas, the education levels and the cross-product), since their results are statistically insignificant.

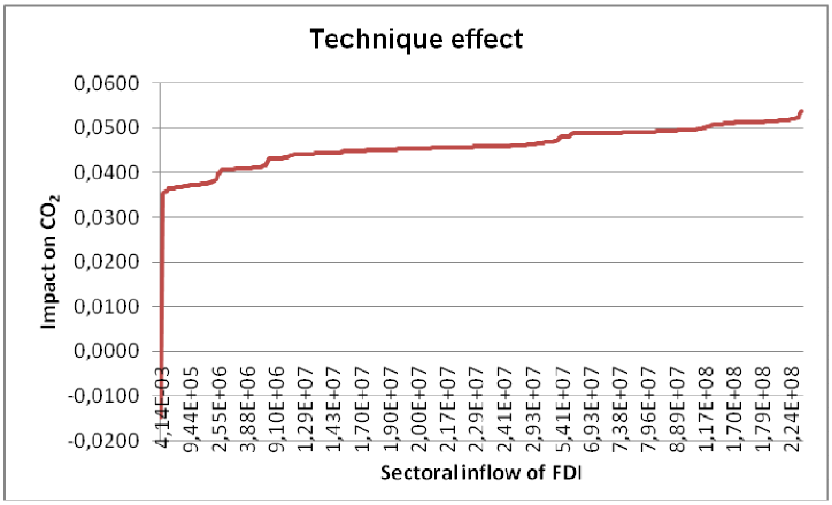
3.5.3. Discussion and conclusions.

With reference to 30 OECD countries and the time span between 1981 and 2005, the work developed in this section has analysed an unbalanced dataset to mainly investigate the relationship between the FDI inflowing in the transport sector – and its connected activities of storage and communication – and the CO_2 emissions from fuel combustion in the same considered sector, to understand whether and how the investment flow generates a detrimental impact on the environment. To this aim, the econometric technique of panel data was used and calibrated to take into account – according to the most recent mainstream literature – technique, scale and composition effects. The following subsections will report the discussion and the conclusion we have reached with the results of this work. With the aim of being as homogeneous as possible and to make for easier reading, we will do this in the next subsections where the variables considered in our analysis will be appropriately grouped.

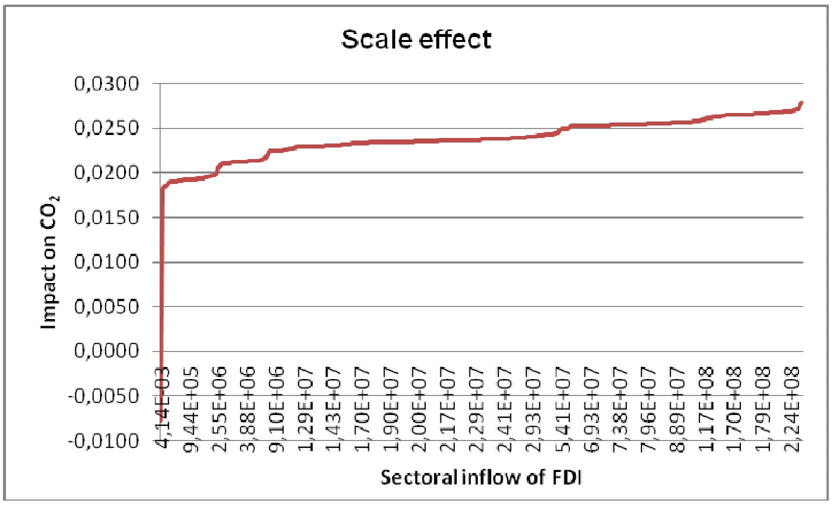
3.5.3.1. The induced-FDI technique, scale and cumulative effects.

The empirical analysis of the CO_2-FDI relationship - that is the main issue of our work - enabled us to observe a positive correlation (+0.0027), when the FDI variable is taken as it is, this showing the negative impact FDI produces on the environment. As already anticipated in the previous section, this would lead us to say that the considered FDI flow impacts negatively on the environment by making our considered environmental variable (CO_2 from fuel combustion deriving from sectoral activities) increase. Similarly to what was said in one of the previous analyses, where a similar relationship was found between FDI and the environmental feature under consideration, our evidence does not allow us to agree with the mainstream thinking which highlights a beneficial role of FDI on the environment. As already said, this would be the result of a technological effect, implicitly living in FDI flows, which make them capable of transferring technology advances, higher efficiency levels in production processes and consequently a minor environmental impact (e.g. Liang, 2006). The detrimental role of FDI on CO_2 was also confirmed by the coefficients we obtained for the scale effect (+0.0014) and the cumulative effect (which was on average equal to +0.0022). However, apart from this straightforward observation of the FDI effect on the considered environmental variable, a more comprehensive view could be expressed through an observation of the trends associated to the technique, scale and cumulative effects of FDI on CO_2. To this purpose, in the graph below (graph 3.30) we plot these effects on the basis of their respective coefficients achieved in the empirical analysis.

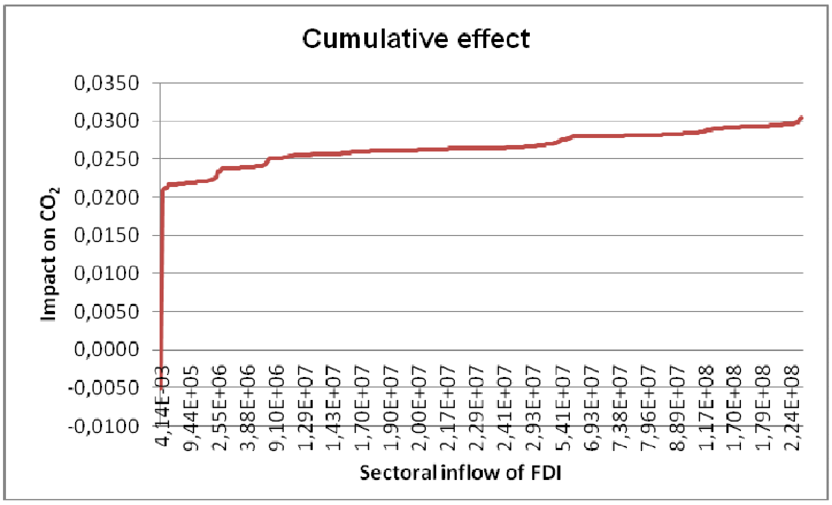
Graph 3.30



Technique effect
Impact on CO_2
Sectoral inflow of FDI
0,0600
0,0500
0,0400
0,0300
0,0200
0,0100
0,0000
-0,0100
-0,0200
4,14E-03
9,44E+05
2,55E+06
3,88E+06
9,10E+06
1,29E+07
1,43E+07
1,70E+07
1,90E+07
2,00E+07
2,17E+07
2,29E+07
2,41E+07
2,93E+07
5,41E+07
6,93E+07
7,38E+07
7,96E+07
8,89E+07
1,17E+08
1,70E+08
1,79E+08
2,24E+08



Scale effect
Impact on CO_2
Sectoral inflow of FDI
0,0300
0,0250
0,0200
0,0150
0,0100
0,0050
0,0000
-0,0050
-0,0100
4,14E-03
9,44E+05
2,55E+06
3,88E+06
9,10E+06
1,29E+07
1,43E+07
1,70E+07
1,90E+07
2,00E+07
2,17E+07
2,29E+07
2,41E+07
2,93E+07
5,41E+07
6,93E+07
7,38E+07
7,96E+07
8,89E+07
1,17E+08
1,70E+08
1,79E+08
2,24E+08



Cumulative effect
Impact on CO_2
Sectoral inflow of FDI
0,0350
0,0300
0,0250
0,0200
0,0150
0,0100
0,0050
0,0000
-0,0050
-0,0100
4,14E-03
9,44E+05
2,55E+06
3,88E+06
9,10E+06
1,29E+07
1,43E+07
1,70E+07
1,90E+07
2,00E+07
2,17E+07
2,29E+07
2,41E+07
2,93E+07
5,41E+07
6,93E+07
7,38E+07
7,96E+07
8,89E+07
1,17E+08
1,70E+08
1,79E+08
2,24E+08

The graph helps us to observe better the generally positively-signed CO_2-FDI relationship. As already pointed out, this relationship is initially characterized by a positive elasticity of the technique effect which makes the considered pollutant increase in response to the increase of FDI. Later, as a result of a further increase of the scale of the economy (which is observed through the scale effect) and when the investment flow reaches a turning point equal to about 1.45E-01 (this intended in terms of FDI per squared km.)[114], the elasticity characterizing the relationship still remains positive but decreases its magnitude: the CO_2 level still grows as FDI grows but at a slower pace with respect to what is observed in the initial phase. As a consequence of these two positively-signed technique and scale effects, the overall impact of FDI on the considered pollutant (observed through the cumulative effect) appears environmentally detrimental although the magnitude of the negative environmental impact decreases as FDI increases.

Our evidence agrees with the evidence achieved in those works which have found positive correlations in the FDI-environment relationship while working with different sets of pollutants (e.g. Bao et Al., 2011; Shahbaz et Al., 2011; He, 2006). For example, He (2006) observes a positive relationship of about 0.098 between the inward FDI stock and the emission levels of SO_2 while investigating a panel dataset built to analyse 29 Chinese provinces over the period between 1994 and 2001. He relates the overall very small negative impact of FDI on the environment to the fact that the country produces a relatively higher pollution efficiency level. This is as a result of the technology effect (and the composition effect as a consequence), which is heavily influenced by the inflow of foreign capital in searching for lower compliance costs of pollution regulation. Similar evidence is achieved in a more recent work by Shahbaz et Al. (2011), where the FDI-environment relationship is investigated over the period between 1985 and 2006 for 110 developed and developing economies. This study finds a significant and positive linear relationship between the inflow of FDI and energy emissions considered in terms of CO_2.

[114] The turning point is achieved here by computing the partial derivative with respect to FDI of our estimated function ($LnCO_2 = 0.0027\ LnFDI + 0.0007\ LnFDI^2$) and then making it equal to zero. The result is LnFDI = -(0.0027/0.0014) = -1.93 which converted from natural logarithmic terms into a real number through exp(-1.93) gives 1.45E-01.

Our evidence, instead, disagrees with other studies belonging to the mainstream literature, where an inverse relationship between FDI and forms of environmental pollution has been found. In all these cases, FDI is thought to play a beneficial role on the environment of receiving countries because of its ability to bring technological advances and higher production efficiency levels together with, as a result, minor polluting emissions (e.g. Gonzales-Perez et Al., 2011; Kirkulak et Al., 2011; Acharyya, 2009; Liang, 2006). Kirkulak et Al. (2011), to give a specific example, prove the existence of this virtuous circle in the FDI-environment relationship while using a panel-data technique to examine the impact of the FDI inflow on air pollution in China between 2001 and 2007. The same evidence is reached by some other studies, which have focused on the case of India and analysed a database containing a time series from 1980 to 2003, especially related to FDI inflowing in the country and CO_2 emission levels (e.g. Acharyya, 2009).

Having said this, however, it must be highlighted how our evidence is certainly characterized by a an positive algebraic sign but it is almost irrelevant from a quantitative point of view. This would lead us to speak more appropriately in terms of the neutral role the FDI inflowing in the "transport and communication" sector exerts on the environmental feature subject of our consideration. It would also induce us to reconsider what was said at the beginning of this section and think that the technological innovation (whose result is the reduction of the environmental impact of production activities) brought in by FDI can still be a valid reason to explain our result of an almost neutral role of FDI on CO_2. As already argued in a previous section, it would be valuable to enter into the qualitative analysis of the sectoral FDI inflow we are considering to look for other possible reasons to explain the evidence we have achieved. It could lead us to understand whether the almost environmentally-neutral role of FDI inflowing in the transport sector of the OECD countries could be the result of a relocation phenomenon whose mechanism attracts major investment quota into “less dirty transport and logistic modes” while pushing away investment from “dirtier modes”. Although this goes beyond the purpose of our work, it can certainly remain ascribed in the research agenda for future work.

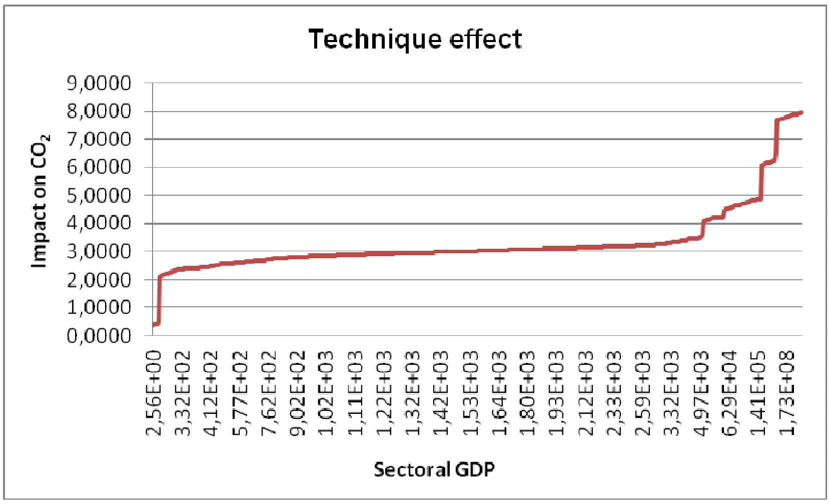
Apart from this, the policy implication arising from the observation of our result would suggest the enforcement of investment (and trade) in considering the almost neutral role it plays on the environment as a result – as already said – of its capacity to be a carrier of technological advances which generate beneficial effects on the environment.

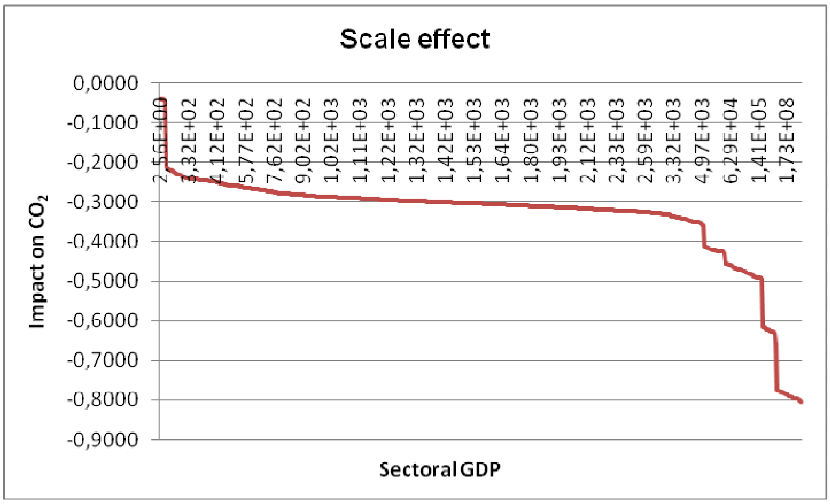
3.5.3.2. The induced-GDP technique, scale and cumulative effects.

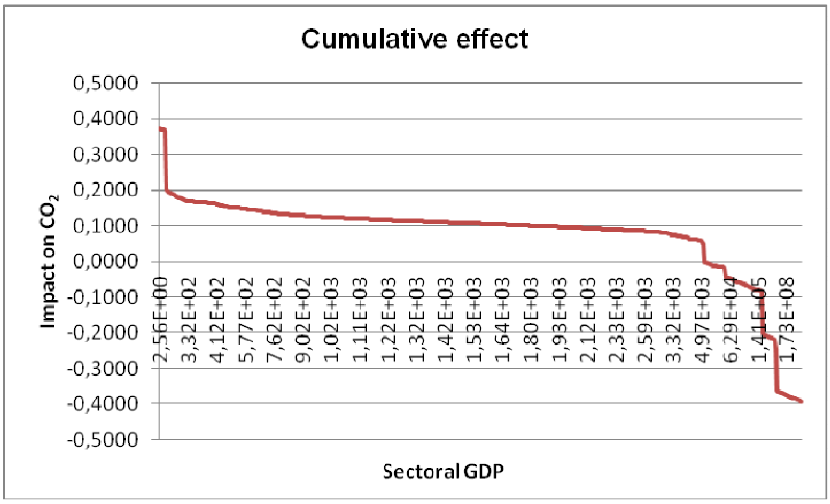
With regard to the relationship between GDP and CO_2, the result achieved from our model estimation showed that the sectoral GDP – which in isolation represents the induced-GDP technique effect – is positively correlated (+0.4104) to CO_2 from fuel combustion generated by the sectoral activities. This result disagrees with the expectations expressed in that part of the literature, which sees a beneficial impact on the environment deriving from the technological advance implicitly existing in the rise of GDP. However, it goes along – if read in relationship with the result denoting the scale effect – with those expectations associated to the results achieved in those works specifically linked to the Environmental Kuznet's Curve (EKC) hypothesis. In fact, when GDP is considered in its squared form – this representing the scale effect – a negative correlation (-0.0207) with CO_2 appears. Our outcomes would prove that in an initial phase, when GDP experiences certain levels of increase, the environment suffers from deterioration. Nevertheless, when further improvements of GDP go beyond those certain levels – whose condition is hypothesized by the GDP squared variable that is the scale effect in our model – the effect on CO_2 turns out to be beneficial to the environment. This beneficial role of GDP on CO_2 is also confirmed by the cumulative effect which is achieved - as we are aware - from the algebraic sum of the technique and scale effects. It is equal to -0.2063 (if actually computed at the GDP sample mean) as a result of the dominance of the scale effect over that of the technique.

The trends of each single effect are plotted in the graph below (graph 3.31) for a better understanding of their behaviours in the context of the relationship between CO_2 from sectoral fuel combustion and GDP (considered in per-capita terms).

Graph 3.31


Technique effect
9,0000
8,0000
7,0000
6,0000
5,0000
4,0000
3,0000
2,0000
1,0000
0,0000
Impact on CO_2
2,56E+00
3,32E+02
4,12E+02
5,77E+02
7,62E+02
9,02E+02
1,02E+03
1,11E+03
1,22E+03
1,32E+03
1,42E+03
1,53E+03
1,64E+03
1,80E+03
1,93E+03
2,12E+03
2,33E+03
2,59E+03
3,32E+03
4,97E+03
6,29E+04
1,41E+05
1,73E+08
Sectoral GDP


Scale effect
0,0000
-0,1000
-0,2000
-0,3000
-0,4000
-0,5000
-0,6000
-0,7000
-0,8000
-0,9000
Impact on CO_2
2,56E+00
3,32E+02
4,12E+02
5,77E+02
7,62E+02
9,02E+02
1,02E+03
1,11E+03
1,22E+03
1,32E+03
1,42E+03
1,53E+03
1,64E+03
1,80E+03
1,93E+03
2,12E+03
2,33E+03
2,59E+03
3,32E+03
4,97E+03
6,29E+04
1,41E+05
1,73E+08
Sectoral GDP


Cumulative effect
0,5000
0,4000
0,3000
0,2000
0,1000
0,0000
-0,1000
-0,2000
-0,3000
-0,4000
-0,5000
Impact on CO_2
2,56E+00
3,32E+02
4,12E+02
5,77E+02
7,62E+02
9,02E+02
1,02E+03
1,11E+03
1,22E+03
1,32E+03
1,42E+03
1,53E+03
1,64E+03
1,80E+03
1,93E+03
2,12E+03
2,33E+03
2,59E+03
3,32E+03
4,97E+03
6,29E+04
1,41E+05
1,73E+08
Sectoral GDP

The trends reported in the graph allow us to observe in detail what would happen in our investigated relationship on the basis of the results achieved from the empirical analysis. Due to the technique effect, the relationship is characterized by a positive elasticity at an initial stage. Hence, CO_2 emissions rise in response to GDP increases. At a later stage, when the considered GDP measure reaches a level we have computed at about 2.01E+04, the elasticity of the relationship changes its algebraic sign and becomes negative as a result of the scale effect and the CO_2 emissions level declines as GDP further increases[115].

As already anticipated, the evidence we have achieved allows us to broadly argue in favour of those works which support the existence of an inverted-U relationship between GDP and pollution, namely the Environmental Kuznet's Curve (EKC). This issue has been amply debated in the scientific literature and different veins of thinking exist. For example, authors such as Mazzanti et Al. (2007) and Shafik and Bandyopadhyay (1992) work on different sets of pollutants (CO_2 among these) and show how a linear effect - in the sense of the EKC - between economic growth and most of the pollutants they take into consideration can be proven. Another work pro the existence of the EKC investigates the case of France while methodologically taking into account, as an estimation method, the autoregressive distributed lag (ARDL) approach to co-integration and finds significant evidence of the existence of a relationship between GDP and CO_2 in the sense of the EKC (Iwata et Al., 2010). Some other studies find, however, evidence to support both the existence and inexistence of the relationship implied by the EKC hypothesis, depending quite often on the geographical scale (whether local or global) at which a considered pollutant is taken into consideration (e.g. Lieb, 2003).

As a counterfactual evidence, other authors find themselves unable to identify or to fully confirm the existence of the EKC while working with different sets of pollutants and adopting various techniques of econometric analysis to investigate the relationship between GDP and the pollutant agent considered time

[115] For the clarity of computation, we obtain this turning point from making equal to zero the partial derivative with respect to GDP of our estimated function ($LnCO_2$ = 0.4104 LnGDP - 0.0207 $LnGDP^2$). The result is LnGDP = 0.4104/0.0414 = 9.91 which, converted from natural logarithmic terms into a real number through exp(9.91), gives 2.01E+04.

by time (i.e. Stern, 2004[a]; 2004[b]; Perman & Stern, 2003; Yandle et Al., 2002). A more recent work specifically focusing on the OECD area between 1960 and 2003 employs a semi-parametric method of generalized additive models to enable the use of more flexible functional forms and does not find any useful relationship between economic growth and CO_2 reduction. In more detail, the authors of this work divide the model into technique, scale and composition effects and find that the technique effect is not enough to reduce CO_2 emissions (and energy use as a broader investigated proxy), except for high-income countries (Tsurumi & Managi, 2010).

To remain within the OECD context and, more specifically, in relation to Canada, further analysis employing semi-parametric and flexible nonlinear parametric modelling methods in an attempt to provide more robust inferences finds very little evidence (at least not enough to provide an adequate statistical support) to confirm the validity of the existence of the EKC hypothesis as the result of the relationship between GDP and CO_2 (He & Richard, 2010). As an additional evidence against the existence of the EKC hypothesis, Aslanidis and Iranzo (2009) employ econometric techniques for smooth transition regressions to investigate a panel data containing information on CO_2 emissions for non-OECD countries between 1971 and 1997 and do not find any evidence of EKC. Some other investigations, although focusing on Japan (which is an OECD partner) and China (as a non-OECD country) to investigate the relationship between economic growth and CO_2 (the analysis also separately considers SO_2 as a further pollutant) over the last 30 years, find no evidence of EKC (e.g. Yaguchi et Al., 2007).

Apart from this very brief report on the different views the scientific debate has produced to support or not the existence of the EKC, the result we have achieved from our empirical analysis would induce us to highlight what follows to the purpose of some policy reflections. A better look at the quantitative aspect of our model estimation results, although proving the existence of a positive role played to some extent by economic growth on the environment, would induce us to moderately accept the policy implication associated to prove the existence of the EKC hypothesis. It is based on the belief that country or population richness per sé can be seen as a driver for pollution abatement. In fact, if we especially consider the cumulative effect of our CO_2-GDP relationship and assess its very low quantitative relevance (equal to about -0.2063 if computed at the GDP sample mean), we would have some difficulty to unconditionally accept the above-mentioned policy prescription, although it cannot be denied that a growth of GDP beyond certain thresholds generates very little beneficial effect on the environmental feature subject of our analysis.

3.5.3.3. The impact of FDI on CO_2 through GDP.

Similarly to what has been done in the previous analyses and considering the realistic assumption that FDI is a component of GDP, in this sub-section we proceed to assess how the sectoral level of CO_2 from fuel combustion is affected by the sectoral FDI inflow through GDP.

Once again, by recurring to the same estimation strategy used for the other analyses in this work and while considering our data in first-differences, we run OLS, FE and RE estimations of the following log-log functional relationship:

$$GDPsctr_{it} = \alpha + \beta_1\ FDIsctr_{it} + \beta_2\ FDIsctr^2_{it} + \beta_3\ SCTRrel_{it} + \beta_4\ MKTopn_{it} + \beta_5\ CRpr_{it} + \varepsilon_{it}$$

where: *i* and *t* (1981-2005) represent the cross-sectional and temporal units in our panel respectively; *GDPsctr* is the gross-domestic product normalized in terms of per-worker in the considered sector; *FDI* and *FDI*^{2} are the linear and quadratic forms of the sectoral inflow of FDI per-worker in the sector; *SCTRrel*, *MKTopn* and *EDU* respectively represent the sectoral relevance, the market openness and the education levels observable in our considered economies and they are used exactly in the same terms as those used for the estimation of model [4]; ε is the error term[116].

[116] The variables considered in this new functional relationship are the same as those used for the analysis of model [4] except for GDP (which was considered in per-capita terms and now in per-worker in the considered sector) and for FDI and FDI^2 (which were both normalized per squared km. in estimating model [4] and now expressed in terms of per-worker in the sector).

The table below (tab. 3.25) shows the estimation results we have achieved. They are produced on the basis of robust standard errors generated through the same estimation strategy used for the previous analyses[117].

Tab. 3.25 – Panel data estimation results.

GDP dep. var.	OLS	FE	RE
FDIsctr	-.0032*** (.0011877)	.0027** (.0011963)	.0032** (.0015632)
$FDIsctr^2$	-.0002 (.0004038)	-.0001 (.0003782)	-.0002 (.0003685)
SCTRrel	.6006*** (.1485679)	.6324*** (.1255835)	.6006*** (.1363481)
MKTopn	-.8875*** (.0609852)	-.8916*** (.0538845)	-.8875*** (.0183349)
EDU	.3415 (.5894787)	.5877 (.5477046)	.3415 (.3097445)
Constant	.0367 (.0215472)	.0353* (.0187946)	.0367*** (.0062967)
N. obs.	**262**	**262**	**262**
N. groups	**26**	**26**	**26**
R-squared	**0.9084**	**n.a. with robust estimates**	**Rho = 0**
Adj. R-squared	**n.a. with robust estimates**		

Robust standard errors in parenthesis; P-value: * ≤ 1%, ** ≤ 5%; * ≤ 10%**

The Brush-Pagan test is run for the choice between OLS and FE/RE models and generates a chibar2 = 0.00 with a p-value of 1.0000. This makes us choose the OLS over the FE/RE.

Tab. 3.26 – The Brush-Pagan (LM) test results.

	Var	Sd = sqrt(Var)
GDP	.0938562	.3063596
E	.008474	.0920544
U	0	0
Test: Var(u) = 0	**Chibar2(1)** = 0.00	**Prob > chi2** = 1.0000

Considering the specific interest of analysis in this section, we only focus on the outcome of the GDP-FDI relationship (we find significant when GDP is considered in its linear form only) and we do not take into consideration any other result achieved in this estimation. The identification of the impact FDI generates

[117]As already reported in footnote 59, in particular OLS and FE are estimated through the use of *xtscc* Stata program which allows the computation of standard errors robust to forms of spatial and temporal dependence (Hoechle, 2007).

on our considered pollutant through GDP can be achieved by recalling the estimation result achieved for model [4] which we rewrite as follows

$$CO_2 = 0.4104\ GDP - 0.0207\ GDP^2 + 0.0027\ FDI + 0.0007\ FDI^2 + ...$$

from which we compute the partial derivatives of $\partial CO_2 / \partial FDI$ and $\partial CO_2 / \partial GDP$ and the result of the equation we have just estimated

$$GDP = -0.0032\ FDI + ...$$

from which we take the partial derivative of $\partial GDP / \partial FDI$. As already done in the previous sections devoted to this type of analysis, the result is obtained by operating $[(\partial CO_2 / \partial FDI) + (\partial CO_2 / \partial GDP)]\ x\ (\partial GDP / \partial FDI)$ with FDI and GDP considered at their sample mean values (namely, FDI = -0.3915 and GDP = 14.8965 as reported in the table giving the summary of the statistics). The result is equal to +0.0006 and represents the actual measure (in average terms) of the impact FDI exerts on CO_2 as observed through GDP. Its positive sign confirms what has already been observed when analyzing the induced-FDI effects on our considered pollutant although the magnitude of the impact comes out as of minor importance.

Considering the minimal quantitative aspect characterizing the result just achieved, once again we should highlight how - independently from the algebraic sign of the relationship - FDI inflowing in the transport and communication sector of our considered economies plays an almost neutral role on the level of CO_2 emissions from the sectoral fuel combustion.

3.5.3.4. The composition effect.

The attempt to analyze the composition effect in our model was made through the employment of two variables, namely those representing the sectoral relevance and the capitalization level of the considered economies. No comment can be given for the earlier variable since the empirical result did not show statistical significance. The remaining considered variable, however, produced a statistically significant result showing a positive relationship between the computed measure of GCF and the considered type of CO_2. The interpretation of such a result would induce us to say that the more the capitalization level of the considered economies increases, the more the negative impact on CO_2 is. In other terms, those economies which are more materially capitalized (in terms of fixed assets such as plants and machinery, equipment, vehicles, land improvements and buildings) are also more polluting. This result basically confirms what has been found in other works. Although it is a generally accepted perception that capital accumulation brings technological advances, which would generate beneficial effects on the environment, this cannot always be considered as the rule of thumb.

As shown in other studies, the increase and accumulation of fixed assets (plants and machinery, vehicles, buildings, etc.) results in higher production levels, which means more consumption, and therefore more pollution. While dealing with different pollutants, various authors have proven the existence of a positive correlation between emission intensity and capital intensity (e.g. Mazzanti et Al., 2007; He, 2006; Cole & Elliott, 2005; 2003; Antweiler et Al., 2001). To give some specific examples – although dealing with the issue of trade - a Factor Endowment Hypothesis (FEH) is postulated by Antweiler et Al. (2001) while referring to an investigation of the environmental impact of trade liberalization. By using a panel data on city-level ambient SO_2 concentration, they find evidence that a 1% growth in the capital-labour ratio of a country generates a 1% increase of SO_2. In their view, the FEH predicts that liberalization of trade leads to a rise of polluting emissions in those countries characterized by capital abundance. Vice-versa for those countries characterized by capital scarcity.

In replicating this study, Cole and Elliot (2003) extend the analysis to take into consideration other pollutants such as CO_2, NO_X and Biological Oxygen Demand (BOD). They also find statistically significant positive correlations, which confirm that the higher the capital to labour ratio is, the higher the pollution intensity is. In light of what has been said so far, we should recognize that technological progress certainly plays a role in abating pollution, but we have to accept that it might be unable to seriously overtake the problem as capital accumulation proceeds at a faster pace than the actual implementation of technological advances.

The policy implication associated to what has just been discussed can rely on the recognition that capital accumulation (which broadly means the production of public and private goods and services) may be realized in various ways, including those which could be detrimental to the environment. This also implies the recognition of the existence of externalities, whose solution can be somehow found in the policy approach which calls for the implementation of environmental taxation, although monetizing environmental values is not an easy thing – sometimes impossible – to do. All this is food for thought on what type of taxation policy would significantly rise capital formation (selective business tax-incentive, personal tax cuts, etc.).

3.5.3.5. Other evidence.

Our model estimation found the variables represented by the surface of the protected area and the education levels existing in our considered countries statistically insignificant. The outcome related to the cross-product we used in the equation was also observed not to be statistically useful.

The only noteworthy result is the positive relationship found between the variable representing the market openness and our considered pollutant. Our result disagrees with all those works proving the existence of a virtuous relationship between trade - and investment, as a consequence of its strong correlation to trade, which is proven in various studies (e.g. Ghosh, 2007; OECD, 2002[b]) - and environmental pollution. It is, therefore, counterintuitive with respect to what is referred in the mainstream literature which explains the virtuous relationship between trade / investment and the environment through the fact that, where trade / investment is freer, a major efficiency in the allocation of resources is achieved and the decline in environmental pollution is the consequent outcome. This is normally believed to be a natural consequence of the globalization process because of the push it gives to the specialization of economies, whose expected results are of major efficiency in the allocation of the level of resources and of minor environmental impact (OECD, 2002[b]; Lucas et Al., 1992).

However, the evidence in our work agrees with that produced in other studies, where a positive correlation has been found while focusing on different developing and developed countries (e.g. Feridun et Al., 2006; Hill & Magnani, 2002). In addition, if we consider that trade and investment can be seen as the two faces of the same coin, we would feel induced to argue that this result does not disown the result achieved for the induced-FDI effect on CO_2 emissions, since we found them characterized by positive signs. Nevertheless, it must be pointed out that the two results should be read separately since one (the relationship between the FDI inflow and CO_2) is associated to a sectoral dynamic. The other (the relationship between the level of market openness and CO_2) considers the broader picture given by the total figures of import and export and does not represent any sectoral flow dynamics, although it is not excluded that it holds some composing aspect of the transport, storage and communication sector now under consideration.

The policy implication associated to our empirical result would argue in favour of trade and investment agreements holding stricter provisions, while, at the same time, guaranteeing that free trade and investment take place. This should especially be done with regard to those sectors particularly exposed to the risk of generating environmental degradation.

Appendix

Tab. III.1

FDI inflow in the "agriculture and fishing" sector in real million of US Dollars (Source: our computation on OECD data)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Australia	62,378	-24,148	29,129	-2,578	3,991	24,479	50,127	-15,41	46,037	5,7085	276,71	-431,15	15,43	-55,998	70,88	-8,3309	-30,45	13,74	49,384	48,074	3,5461	14,474	-6,5302	143,456	-75,499	**207,4329**
Austria																		15,06	1,0878				2,1311	3,41927	-14,298	**7,396173**
Belgium																							-401,78	-1110,17	-626,93	**-2138,88**
Canada																										
Czech Republic													2,2602	1,1189	8,683		7,3705	8,325	6,4612	8,36	28,475	-1,8602	1,7651	76,5514	4,40177	**151,912**
Denmark		9,3333	-2,692	-3,976	0,944	0,5225		22,483					23,666					-31,1	6,1398	17,804	2,2382	35,218	0,8604	-0,30642	-0,2956	**80,82654**
Finland																										
France	-4,366	6,2794	14,129	-35,34	7,314	-3,456	16,643	20,322	-38,69	12,988	14,6	9,554	25,288	24,816	5,663	27,449	-1,183	110	47,84	7,373	6,1461			7,9789	-5,4991	**275,8789**
Germany			0,6031		0,97	-3,242	2,2554	14,986	-2,02	15,849	0,7094	7,3586	8,9352	21,908	3,034	-456,75	-400	-400	-375,1	-13,82	50,047	-10,065	25,578	0	-19,797	**-1528,19**
Greece								22,842			12,364	11,036									3,0716	6,6796	0,8953	-8,05872		**48,82901**
Hungary																			35,942		122,37	37,104	21,855	15,4541	5,77876	**238,5069**
Iceland										-0,0622	0,06	-2,6931	-0,352	-0,0322	-0,05	0,2	-0,101	0,095	0,3929	0,028	-0,215	-0,0388	0,0349	0,01376	0,00708	**-2,71299**
Ireland													0													
Italy	-1,492	2,3476	3,0385	0,8368	0,749		2,0838	10,108	8,3051	1,0171	-2,8447	2,7989	3,9398	27,096	5,682	36,079	42,766	17,7	18,484	11,98	171,21	-88,752	103,38	218,843		**595,3511**
Japan																									-1,608	**-1,60796**
Korea Republic					0,373	0,2394		6,2789		-0,122		-1,7241		0,1111	0,87		35,684	120,6	52,143	3,2	-17,16	-1,5534	-4,434	0,36697	0,44248	**195,3431**
Luxembourg																										
Mexico	10,169	9,5238	60	7,3529	7,143	12,676	29,73	-23,68	-2,532	96,341	64,706	28,736	36,364	33,333	91,43	33,723	11,474	29,38								**535,8615**
Netherlands		-6,5381	-10,24	-9,624	11,18	-7,475	11,339	2,6632	-5,371	21,43	18,248	-3,2678	-72,21	26,864	-17,6	5,5617	227,1	31,23	40,23	-16,59	21,95	31,109	29,841			**329,8345**
New Zealand				1,6647	0,706	-1,47	1,5946	-7,743	0,7557																	**-4,49313**
Norway														3,6211												**3,621111**
Poland														2,8889	13,26	4,6809	5,2632	8,646	58,163	10,9	9,0196	8,6408	36,698	75,5046	44,7788	**278,4447**
Portugal	15,254	7,9365	3,0769	1,4706	5,714	4,2254	17,568	31,579	27,848	30,49	24,707	19,539	17,047	3,6078	1,08											**211,1437**
Slovak Republic											0									-0,19	-0,04	1,5	8,8283			**10,09811**
Spain	33,102	71,256	32,908	237,86	29,8	69,635	116,6	114,55	254,74	212,29	56,953	85,516	65,385	31,742	21,76	34,93	11,962	27,85	2,1745	10,137	-12,29	52,153	26,643	-115,12		**1472,526**
Sweden									0,1962	0,2061					0,304		-1,379	4,064	198,84	4,039	0,6637	1,4981				**208,4369**
Switzerland																										
Turkey																				9			0,9434	5,50459	4,42478	**19,87276**
United Kingdom			2,3323	1,9559	-1,833	-10,32	50,819	56,17	28,985	41,156	14,527	90,792	-25,59	27,212	12,01	8,3011	10,345	10,35	23,112	27,248	15,532	11,651	-44,681	65,555		**415,6264**
United States	247,46	152,38	175,38	30,882	2,857	180,28	228,38	-113,2	93,671	-54,878	-78,824	17,241	-180,7	115,56	-128	-38,298	235,79	102,1	56,122	207	51,961	-321,36	-217,92	71,5596	-52,212	**783,0101**
Total OECD Countries	**362,5**	**228,37**	**307,67**	**230,51**	**69,913**	**266,09**	**527,14**	**141,99**	**411,92**	**382,411**	**401,91**	**-166,26**	**-80,52**	**263,84**	**88,73**	**-352,45**	**154,64**	**68,43**	**221,41**	**334,54**	**456,53**	**-223,6**	**-415,9**	**-549,45**	**-736,3**	**2394,063**

Tab. III.2

FDI stock in the "agriculture and fishing" sector in real million of US Dollars (Source: our computation on OECD data)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Australia			405,21	506,54	446,54	356,8521	480,7	491,07	1016,8	514,7	1291,1	582,88	583,91	684,62	604,1	524,83	414,483	401,02	694,04	698,59	499,98	623,4078	958,288	770,188	634,618	**14184,5**
Austria						10,78732	14,414	13,404			3,8518	3,6448	3,0886	6,0089									22,6387	23,7431		**101,581**
Belgium																										
Canada																										
Czech Republic																	5,56105	23,695	18,249	34,368	46,507	19,72524	10,3311	99,1101	68,2504	**325,797**
Denmark											20,889			37,081				32,625	20,004	17,583	13,173	27,41748	20,5915	2,34954	1,67876	**193,392**
Finland																										
France									209,51	268,91	208,94												439,667	486,107		**1613,14**
Germany		50,094	40,105	32,701	41,789	59,50563	72,631	65,779	76,795	133,05	91,571	111,81	106,64	113,35	128,91	275,67	134,513	140,1	217,32	144,23	127,87	158,832	187,067	171,2		**2681,53**
Greece																		2,9708	4,8439	2,791	0,1471	1,924272	2,4783	3,74862		**18,904**
Hungary												36,524	85,297	99,47				160,04	165,27		237,42	393,4058	229,146			**1406,57**
Iceland										1,9646	1,4824	-1,3448	-0,42	-0,211	-0,2663	0,4191	0,30421	0,4354	1,101	1,128	0,5422	0,646602	0,81132	0,88624	0,00708	**7,48548**
Ireland																										
Italy		37,079	35,254	31,174	28,949	36,28169	51,993	58,459	60,767	86,341	78,72	40,645	85,383	116,66	120,03	162,56	205,676	270,35	269,48	250,3	367,21	253,5204	447,316	740,655		**3834,8**
Japan																									31,5062	**31,5062**
Korea Republic										3,9024	3,7647	1,954	1,9318	2	2,8261	2,766	38,4211	158,54	207,55	206,6	185,39	182,0388	172,453	168,073	162,566	**1500,78**
Luxembourg																										
Mexico	74,576	33,333	66,154	8,8235	8,5714	19,71831	47,297	57,895	105,06	259,76	292,94	241,38	105,68	145,56	202,17	380,85	344,211	440,94	599,9	652,08						**4086,89**
Netherlands				68,781	94,827	131,0732	162,7	124,37	141,42	177,52	136,19	122,29	77,869	76,847	49,455	72,607	135,7	171,36	162,99	133,06	159,84	337,0097	7,14906	7,49817		**2550,56**
New Zealand																										
Norway														5,0944										389,084		**394,179**
Poland														6,6667	20,652	24,787	24,4211	33,958	149,9	158,7	173,43	180,1942	224,434	358,44	360,796	**1716,38**
Portugal															36,389											**36,3891**
Slovak Republic																		1,7208	3,8449	3,879	15,572	20,53398				**45,5503**
Spain																										
Sweden																										
Switzerland																										
Turkey																				45	45,098	26,21359	41,5094	217,431	286,726	**661,978**
United Kingdom				35,716			336,36	330,95	325,16	366,79	369,74	366,7	158,22	119,79	107,83	112	100,968	90,106	225,97	219,35	199,07	236,2932	242,45	336,666		**4280,14**
United States		1663,5	1766,2	1691,2	1580	1760,563	1689,2	1468,4	1708,9	1776,8	1467,1	1386,2	1554,5	1792,2	1788	1737,2	2136,84	2155,2	2265,3	2416	2457,8	1938,835	1899,06	2022,94	1946,02	**44068**
Total OECD Countries	**74,576**	**1784**	**2312,9**	**2374,9**	**2200,7**	**2374,782**	**2855,3**	**2610,4**	**3644,4**	**3589,8**	**3966,3**	**2892,7**	**2762,2**	**3205,2**	**3060,1**	**3293,7**	**3541,1**	**4083,06**	**5005,8**	**4983,7**	**4529,1**	**4399,998**	**4905,39**	**5798,12**	**3492,17**	**83740,1**

Tab. III.3

CH4 without land use, land use change and forestry in mln. tons CO2 equivalent (Source: UN from http://data.un.org)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total	Pop. @ 2005	Emission p/cap @ 2005
Australia	114,653	114,1867	114,3849	114,1305	112,7588	114,4354	111,9276	115,1952	114,2747	114,0417	116,2821	119,8266	117,6502	114,2727	114,487	113,8748	**1836,382**	20310000	5,60683E-06
Austria	9,184053	9,162638	8,875038	8,852111	8,659917	8,543036	8,353696	8,076732	7,955027	7,781037	7,621742	7,507018	7,380937	7,382764	7,224403	7,071422	**129,6316**	8292000	8,528E-07
Belgium	10,40416	10,20434	10,04187	9,883043	9,865661	9,870256	9,569092	9,428878	9,240189	9,057041	8,774728	8,415181	7,946251	7,591839	7,47067	7,275448	**145,0386**	10398000	6,99697E-07
Canada	74,33931	76,13764	80,33056	82,69579	85,59478	89,23332	92,74305	94,34462	95,61833	95,43374	98,1629	99,62086	99,48296	100,3893	102,0013	102,1592	**1468,288**	32271000	3,16566E-06
Czech Republic	18,46146	16,80407	15,79687	14,7916	13,8864	13,6443	13,43526	12,9972	12,54068	12,04357	12,07291	12,22826	12,04237	11,72698	11,54472	11,61571	**215,6323**	10192000	1,13969E-06
Denmark	5,729471	5,817322	5,845452	6,006162	5,928395	6,005771	6,137284	6,027898	6,055247	5,931376	5,920808	6,054334	6,017674	6,001203	5,807287	5,662245	**94,94793**	5417000	1,04527E-06
Finland	6,288819	6,275294	6,249582	6,26622	6,217928	6,073048	6,002385	5,925433	5,730671	5,598502	5,381093	5,258216	5,060193	4,865911	4,698326	4,484112	**90,37573**	5246000	8,54768E-07
France	68,67452	69,11807	68,87318	69,17545	69,09207	69,55015	69,02888	65,72142	65,54913	64,92904	64,54786	62,91451	61,22825	59,69765	58,01411	57,34918	**1043,463**	60991000	9,40289E-07
Germany	99,26615	93,88123	89,75347	89,30082	84,74602	81,4762	78,37227	74,53241	69,27853	68,56471	64,70444	61,41751	57,85186	53,7573	49,58278	47,6782	**1164,164**	82652000	5,76855E-07
Greece	8,981743	8,973785	9,017229	8,983916	9,062794	9,063463	9,211823	9,170977	9,214969	9,010255	8,842435	8,445697	8,416036	8,338971	8,283503	8,262338	**141,2799**	11100000	7,44355E-07
Hungary	9,455493	9,281709	8,580976	8,303923	8,147103	8,216599	8,313475	8,247717	8,261176	8,270855	8,271424	8,096576	8,182396	8,182979	7,957273	7,891013	**133,6607**	10086000	7,82373E-07
Iceland	0,456203	0,453721	0,450371	0,452406	0,457629	0,452915	0,458708	0,462225	0,464226	0,463021	0,454317	0,458405	0,444127	0,444595	0,437189	0,438217	**7,248274**	296000	1,48046E-06
Ireland	13,46677	13,61055	13,70353	13,79267	13,76021	13,79926	14,04511	14,10805	14,36617	14,04512	13,53947	13,28804	13,36258	13,94235	13,35563	13,26181	**219,4473**	4143000	3,20102E-06
Italy	41,61415	42,92645	42,31	42,60102	43,2658	44,11792	44,17715	44,51573	44,22235	44,30703	44,29082	42,9309	41,83605	41,08599	39,92839	39,5936	**683,7234**	58646000	6,75129E-07
Japan	33,38553	33,14815	32,88874	32,61427	31,92057	30,96416	30,25313	29,15885	28,31716	27,66432	26,97969	26,18649	25,228	24,74587	24,3519	23,92996	**461,7368**	127897000	1,87103E-07
Korea Republic																		47870000	
Luxembourg	0,46004	0,468606	0,462728	0,473768	0,455176	0,46975	0,478476	0,477617	0,479218	0,49089	0,486637	0,483629	0,481879	0,475254	0,471166	0,469182	**7,584017**	457000	1,02666E-06
Mexico																		104266000	
Netherlands	25,43771	25,68738	25,17462	24,91071	24,08675	23,77369	23,00798	21,9883	21,14276	20,10936	19,22981	18,84037	17,98346	17,54582	17,252	16,84492	**343,0156**	16328000	1,03166E-06
New Zealand	25,48561	25,41975	24,88533	25,05868	25,71306	25,74308	26,00352	26,54262	26,02222	26,32921	27,15801	27,19102	26,96607	27,22207	27,11236	27,29655	**420,1492**	4097000	6,66257E-06
Norway	4,635138	4,692495	4,766207	4,849529	4,937288	4,934324	4,972425	5,009317	4,897363	4,76419	4,907941	4,922524	4,752076	4,777024	4,741407	4,582022	**77,14127**	4639000	9,87718E-07
Poland	47,70893	46,12961	43,90739	43,66812	43,80605	43,64225	43,1101	43,27499	42,35293	41,94342	38,99585	37,94188	37,20937	37,68223	36,82762	37,04359	**665,2443**	38196000	9,69829E-07
Portugal	10,1034	10,37397	10,49664	10,5091	10,98836	11,23373	11,36212	11,57229	12,03515	12,2754	11,52535	11,85805	12,16961	12,21287	11,93399	12,23636	**182,8864**	10528000	1,16227E-06
Slovak Republic	5,39563	5,146609	4,851874	4,467915	4,45194	4,64444	4,576375	4,626137	4,86347	5,071156	4,684807	4,733737	5,329805	4,958525	4,925825	4,628156	**77,3564**	5387000	8,59134E-07
Spain	28,03135	28,60682	29,51211	29,80198	30,44236	31,04852	32,45061	33,47271	34,52262	34,70948	35,8052	36,70396	37,11624	37,54564	37,49031	37,397	**534,6569**	43397000	8,61742E-07
Sweden	6,71922	6,70554	6,792326	6,840663	6,7637	6,676878	6,64146	6,580274	6,414708	6,264386	6,080711	6,060241	5,885925	5,724969	5,739007	5,602821	**101,4928**	9038000	6,19918E-07
Switzerland	4,373818	4,350366	4,239462	4,099654	4,004835	3,986736	3,931383	3,852973	3,79729	3,747089	3,696707	3,70848	3,646337	3,542416	3,526715	3,541174	**62,04543**	7424000	4,7699E-07
Turkey	29,20719	33,1725	36,66441	38,97879	39,18682	42,53878	44,98502	46,44509	47,70584	48,82587	49,26891	48,70285	46,87465	47,75687	46,28971	49,31694	**695,9203**	72970000	6,75852E-07
United Kingdom	103,672	102,8864	101,3675	98,27856	91,26547	90,27982	87,86916	83,02212	78,3605	73,09425	68,5139	62,52631	59,51199	53,5415	51,68323	49,72705	**1255,6**	60245000	8,25414E-07
United States	601,6045	602,2548	604,2936	592,3777	599,4752	594,1809	588,528	579,6207	569,08	558,0635	555,2848	549,3621	547,0965	550,6363	538,6367	527,3588	**9157,854**	299846000	1,75877E-06
Total OECD Countries	**1407,195**	**1405,877**	**1404,516**	**1392,165**	**1388,941**	**1388,599**	**1379,946**	**1364,398**	**1342,763**	**1322,83**	**1311,485**	**1295,684**	**1277,154**	**1266,048**	**1241,774**	**1226,592**	**21415,97**	**1172625000**	**1,04602E-06**

Tab. III.4

CO2 from fuel combustion in Agriculture and Fishing in Million tons (Mt) (Source: IEA estimations)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total	Pop. @ 2005	Emission p/cap @ 2005
Australia	2,97	3,27	2,97	3,38	3,28	3,23	3,37	3,27	3,47	3,36	3,38	3,43	3,55	3,63	3,76	3,77	3,92	4,00	4,09	4,16	4,17	4,99	5,67	6,00	6,36	**97,45**	20310000	3,13146E-07
Austria	2,51	2,44	2,24	2,40	2,29	2,06	1,98	1,81	1,68	1,23	1,19	1,15	1,04	0,98	1,01	1,02	1,02	1,03	1,04	0,97	0,98	0,96	0,97	0,95	0,93	**35,88**	8292000	1,12156E-07
Belgium	1,36	1,35	1,24	1,13	1,12	1,40	1,36	1,78	1,71	1,51	1,68	2,20	2,42	3,06	3,44	3,85	3,27	2,91	2,68	2,06	2,16	1,81	2,51	1,92	2,48	**52,41**	10398000	2,38507E-07
Canada	5,19	4,89	9,36	5,64	5,81	5,84	5,92	6,30	7,14	7,27	7,32	7,91	8,26	8,35	8,85	9,39	9,79	9,43	9,70	9,87	8,76	7,79	8,00	7,98	7,87	**192,63**	32271000	2,43872E-07
Czech Republic	4,23	3,79	3,99	4,04	3,90	4,03	4,27	4,37	4,31	3,74	3,68	2,67	3,05	3,03	3,41	1,83	1,37	1,23	1,56	1,66	1,52	1,41	1,35	1,32	1,29	**71,05**	10192000	1,2657E-07
Denmark	3,01	2,55	2,51	2,27	1,53	1,57	1,52	1,46	1,39	2,25	2,37	2,33	2,13	2,12	2,10	2,22	2,20	2,12	2,12	2,12	2,08	2,03	1,96	1,84	1,84	**51,64**	5417000	3,39671E-07
Finland	1,62	1,71	1,60	1,71	1,79	1,82	1,92	2,02	2,07	2,09	1,78	1,94	1,93	1,68	1,64	1,68	1,64	1,68	1,66	1,74	1,78	1,75	1,73	1,72	1,70	**44,40**	5246000	3,24056E-07
France	8,83	8,78	8,57	8,60	8,50	8,53	8,57	8,61	9,89	10,40	10,38	10,18	9,44	9,01	9,56	9,68	9,89	9,87	9,74	9,50	9,49	9,32	8,89	8,97	8,74	**231,94**	60991000	1,433E-07
Germany	7,66	7,30	7,28	7,68	7,89	7,80	7,49	7,50	7,58	7,39	8,42	8,21	6,06	6,17	6,01	6,14	6,13	6,16	6,09	6,26	6,11	5,83	5,90	5,90	5,57	**170,53**	82652000	6,7391E-08
Greece	1,98	2,11	2,38	2,59	2,65	2,36	2,62	2,79	2,81	2,72	3,01	2,80	2,72	2,74	2,55	2,60	2,59	2,59	2,60	2,60	2,63	2,86	3,07	2,62	2,69	**65,68**	11100000	2,42342E-07
Hungary	3,63	3,46	3,01	3,31	3,29	3,09	3,23	3,07	2,95	2,59	2,11	1,61	1,50	1,58	1,53	1,67	1,65	1,66	1,71	1,59	1,45	1,49	1,39	1,29	1,23	**55,09**	10086000	1,21951E-07
Iceland	0,51	0,53	0,55	0,51	0,47	0,53	0,58	0,60	0,62	0,66	0,70	0,75	0,78	0,79	0,78	0,85	0,83	0,79	0,77	0,73	0,65	0,71	0,75	0,72	0,71	**16,87**	296000	2,39865E-06
Ireland	0,07	0,05	0,03	0,04	0,04	0,64	0,61	0,60	0,60	0,65	0,67	0,68	0,69	0,78	0,90	0,72	0,75	0,74	0,78	0,81	0,82	0,82	0,82	0,79	0,82	**14,92**	4143000	1,97924E-07
Italy	5,78	5,75	5,80	5,82	6,24	6,27	6,81	7,26	8,31	8,35	7,72	7,93	8,62	8,63	8,78	8,80	8,51	8,45	8,24	8,04	8,34	8,29	8,86	8,30	8,37	**192,27**	58646000	1,42721E-07
Japan	8,80	21,09	21,70	24,67	23,68	24,74	26,51	28,59	28,22	20,70	21,70	21,21	20,22	19,58	19,00	19,72	18,95	18,35	17,69	15,72	15,01	14,77	14,14	13,65	12,72	**491,13**	127897000	9,9455E-08
Korea Republic	2,10	2,06	2,08	2,29	2,38	3,16	3,34	3,79	4,20	4,69	5,13	5,78	6,49	7,39	8,02	8,99	9,87	8,46	9,23	9,70	10,21	9,85	8,75	7,95	7,42	**153,33**	47870000	1,55003E-07
Luxembourg	0,02	0,03	0,02	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,02	0,02	0,02	0,02	0,04	0,05	**0,56**	457000	1,09409E-07
Mexico	6,38	6,60	5,62	5,53	5,63	5,46	5,79	6,02	5,31	5,17	5,33	5,36	5,39	4,74	5,36	5,30	5,71	5,66	6,27	6,37	6,27	6,04	6,49	6,76	7,34	**145,90**	104266000	7,03969E-08
Netherlands	0,73	0,94	0,78	5,18	5,52	6,26	6,57	6,65	6,80	7,98	8,77	8,64	9,19	8,40	9,37	8,81	8,64	8,94	9,36	8,94	8,87	8,81	7,88	8,13	8,48	**178,64**	16328000	5,19353E-07
New Zealand	0,68	0,77	0,75	0,77	0,74	0,68	0,66	0,63	0,62	0,96	0,87	0,90	0,88	0,94	0,97	1,00	1,06	1,10	1,09	1,01	0,98	1,07	1,18	0,99	1,10	**22,40**	4097000	2,68489E-07
Norway	0,64	0,62	0,59	0,61	0,61	0,62	0,61	0,62	0,60	0,64	1,83	1,74	1,66	1,75	1,72	1,91	1,92	1,97	1,92	1,79	1,89	1,91	1,89	1,84	1,75	**33,65**	4639000	3,77236E-07
Poland	7,46	7,33	7,16	6,96	7,81	7,56	6,30	7,85	7,96	7,82	8,38	9,69	11,58	13,52	13,04	13,71	14,20	12,84	13,24	12,36	12,21	11,43	11,62	11,92	12,45	**256,40**	38196000	3,2595E-07
Portugal	0,97	1,03	1,16	1,14	1,20	1,20	1,20	1,24	1,28	1,34	1,34	1,34	1,33	1,35	1,34	1,32	1,48	1,67	1,79	1,99	1,34	1,22	1,15	1,53	1,48	**33,43**	10528000	1,40578E-07
Slovak Republic	2,24	2,03	2,00	1,95	1,95	1,90	1,96	1,99	1,95	1,75	1,22	0,91	1,00	0,64	0,60	0,57	0,56	0,50	0,45	0,41	0,36	0,28	0,31	0,34	0,35	**28,22**	5387000	6,49712E-08
Spain	6,06	6,61	6,67	6,76	7,09	6,89	7,22	6,40	3,95	4,17	4,53	4,89	5,06	5,28	5,41	5,37	5,30	4,79	5,45	6,40	5,86	5,79	7,27	8,34	7,74	**149,30**	43397000	1,78353E-07
Sweden	1,52	1,37	1,25	1,29	1,37	1,73	1,61	1,53	1,38	1,36	1,39	1,34	1,19	1,20	1,22	1,27	1,27	1,52	1,19	0,98	1,03	1,22	1,24	1,13	0,98	**32,58**	9038000	1,08431E-07
Switzerland	0,29	0,29	0,29	0,30	0,30	0,30	0,30	0,30	0,31	0,35	0,36	0,36	0,38	0,45	0,46	0,47	0,45	0,50	0,41	0,00	0,00	0,00	0,00	0,00	0,00	**6,87**	7424000	0
Turkey	2,91	3,65	3,97	4,06	4,47	4,37	5,37	5,41	5,21	5,84	5,78	5,90	7,14	7,17	7,73	8,06	8,00	7,92	8,14	8,14	8,12	8,86	7,99	8,99	9,07	**162,27**	72970000	1,24298E-07
United Kingdom	3,14	3,13	3,13	3,08	3,08	3,09	2,90	2,81	2,62	2,66	2,71	2,73	2,72	2,72	2,62	2,87	2,63	2,64	2,39	2,10	2,26	2,00	1,32	1,18	1,41	**63,94**	60245000	2,34044E-08
United States	38,89	36,22	35,49	39,41	50,41	48,91	46,95	48,19	45,80	43,11	43,03	46,88	44,53	45,29	45,33	46,46	46,92	43,11	39,62	42,07	46,28	45,29	39,85	50,77	50,10	**1.108,91**	299846000	1,67086E-07
Total OECD Countries	**132,18**	**141,75**	**144,19**	**153,13**	**165,06**	**166,06**	**167,56**	**173,48**	**170,76**	**162,77**	**166,80**	**171,48**	**170,97**	**172,99**	**176,53**	**180,07**	**180,54**	**172,65**	**171,05**	**170,11**	**171,65**	**168,62**	**162,97**	**173,88**	**173,04**	**4.160,29**	1172625000	1,47566E-07

Tab. III.5

FDI inflow in the "manufacturing" sector in real million of US Dollars (Source: our computation on OECD data)

	1981	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Total**
Australia	1333,32	1735,41	-393,94	968,19	559,77	972,55	1267,36	1750,82	2936,37	1589,80	2114,72	3823,82	3982,29	1874,71	1196,01	1645,44	111,67	933,53	1952,32	1563,86	-1498,90	3279,25	4727,01	35082,86	-42319,87	**31188,36**
Austria																		580,25	471,88	-254,35	690,12	444,67	1759,54	227,96	-796,31	**3123,76**
Belgium																						3844,70	4514,49	8096,05	-3294,11	**13161,13**
Canada	-769,07	1252,18	-831,40	895,98	1509,21	792,66	2131,67	-341,99	3844,18	315,56	-1758,24	968,87	1645,27	3422,24	1939,49	580,36	1965,42	3533,31	2560,12	12122,42						**35778,27**
Czech Republic													414,41	519,60	931,49	680,95	429,85	1336,93	2049,81	2047,49	1621,60	971,72	2475,89	928,36	1635,05	**16043,16**
Denmark		96,95	13,80	16,62	-6,20	14,97	180,22	208,41	214,55	665,31	685,51	609,89	505,40	856,19	609,83	546,76	1322,94	700,02	912,24	2187,07	1713,52	229,66	744,45	468,25	930,84	**14427,20**
Finland	9,84	-20,12	-1,38	24,50	23,98	427,77	-18,75	70,09	149,07	270,22	-44,23	521,67	608,01	1199,46	320,83	705,36	1686,38	1790,74	2507,83	1252,42	-93,07	676,16	1252,25	425,15	-1903,88	**11840,30**
France	1954,52	773,84	921,47	1169,66	884,75	1052,64	2718,87	4232,26	1511,88	2062,92	4995,32	5635,77	3040,89	2797,98	3716,61	4582,37	5372,57	8126,95	8840,64	13605,20	11258,79	18274,68	10706,46	3719,19	8738,47	**130694,71**
Germany			413,34	109,01	8,74	-232,80	-800,70	-2354,90	-135,34	-1337,31	-2205,79	-1932,48	1804,97	-1062,54	1307,65	-1981,13	999,68	-2542,80	28089,77	-3106,63	7512,30	925,95	-2038,77	3305,44	2688,08	**27433,75**
Greece							970,34	708,12	660,07	769,36	626,40	2733,04									74,14	-206,54	234,18	564,81		**7133,91**
Hungary																			1188,35		2056,49	1361,75	682,11	1197,50	2231,60	**8717,79**
Iceland								15,25	29,63	16,02	21,36	-14,90	-1,21	4,70	3,42	86,95	138,84	24,56	40,21	144,17	13,22	59,61	56,77	329,92	600,81	**1569,33**
Ireland			172,06	290,04	277,28	347,30	426,30	321,58	238,20	244,47	415,65	419,44	420,06	336,94	389,48	581,75	575,51						14039,04	4485,14	-2617,69	**21362,56**
Italy	929,04	665,35	1396,66	1236,39	273,84	-1807,88	2288,18	4087,60	1771,86	484,40	2549,12	1711,94	1652,18	391,18	2352,07	672,04	1251,08	1026,36	2047,34	5511,93	4590,26	4796,27	5977,76	2736,68		**48591,64**
Japan	500,00	819,05	952,31	404,41	930,00	698,59	1932,43	3190,79	1483,54	1915,85	2230,59	1849,43	1777,27	2183,33	1631,53	3041,33	2326,23	2487,78	8777,71	7332,84	2647,01	6376,90	3964,44	867,83	-2171,05	**58150,14**
Korea Republic					239,53	344,90	508,50	743,21	641,25	448,54	417,41	436,67	274,77	313,44	536,52	904,47	1558,32	2721,35	3230,82	3223,10	1049,80	709,71	721,23	1286,88	453,36	**20763,79**
Luxembourg																										
Mexico	4281,36	3752,38	4455,38	3858,82	3671,43	4771,83	2795,95	2467,11	3581,01	2331,71	3357,65	3652,87	2087,50	6051,11	4258,70	4980,96	7608,42	5069,06	5440,26	4496,97	2262,14	5356,07	3924,82	4466,28	4612,00	**103591,79**
Netherlands	1902,42	181,30	281,41	450,50	292,83	2037,66	2864,30	2193,28	4814,86	5149,49	1189,92	2653,03	1911,01	2640,67	1796,24	8891,90	4902,29	19611,79	13942,14	9706,02	17947,51	7002,26	5930,86	3964,25		**122257,95**
New Zealand				-28,30	125,54	108,76	162,63	192,74	199,63																	**761,00**
Norway														42,83	827,93	855,69	2981,09	799,61	991,11	1597,65	164,40	-480,36	598,36	457,40		**8835,71**
Poland														806,00	1933,70	1931,28	1566,74	2267,60	1785,51	2085,40	1180,20	1280,29	1825,47	4181,01	2346,19	**23189,39**
Portugal	105,09	95,24	92,31	89,71	140,00	95,77	110,81	292,11	384,82	521,99	451,79	309,17	479,57	637,84	277,28	124,02	285,61	-255,54	-106,24	104,97	-334,59	-193,64	499,38	868,51	-195,32	**4880,63**
Slovak Republic																				846,88	244,38	5,14	298,54			**1394,94**
Spain	930,88	1826,66	1039,20	1290,64	1464,50	2478,07	4185,10	3518,93	5587,74	7620,56	4107,07	5042,37	6101,62	5665,27	3626,09	3416,16	3080,14	4291,74	-938,32	2400,70	5168,00	8427,78	806,77	5999,95		**87137,63**
Sweden									382,54	1662,97	5185,62	-592,18	2040,05	3747,91	11279,12	1332,52	4413,47	6838,01	51108,47	-5496,23	6066,85	580,97	2140,63			**90690,71**
Switzerland						227,90	159,55	624,13	695,80	3402,41	510,40	223,21	-2,31	872,89	1301,11	1879,62	3095,46	2205,49	1999,39	9704,31	-1002,36	418,90	4664,93	2535,72	516,14	**34032,70**
Turkey												632,18	542,05	445,56	422,83	450,00	367,37	576,04	360,41	207,00	908,82	338,83	475,47	349,54	431,86	**6507,96**
United Kingdom	902,46	540,56	2329,38	2064,22	1853,31	1990,25	6761,18	9897,68	15825,89	7033,31	6259,01	4698,99	5707,41	4081,84	7157,17	7092,20	9931,46	17866,76	18354,47	16544,05	17224,29	-2892,52	2804,15	2988,63		**167016,13**
United States	12635,59	4173,02	5670,77	6416,18	12730,00	19869,01	33813,51	42005,26	48865,82	20796,34	8572,94	8658,62	15801,14	22164,44	33926,09	44614,89	39694,74	149243,75	84063,27	105119,00	50067,65	25253,40	17202,83	18592,66	45785,84	**875736,76**
Total OECD Countries	**24715,45**	**15891,82**	**16511,35**	**19256,58**	**24978,49**	**34189,96**	**62457,44**	**73822,49**	**93683,38**	**55963,91**	**39682,22**	**42041,41**	**50792,36**	**59993,62**	**81741,18**	**87615,89**	**95665,28**	**229233,30**	**239669,49**	**192946,21**	**131532,57**	**86841,60**	**90989,04**	**108125,99**	**17672,03**	**1976013,09**

Tab. III.6

FDI stock in the "manufacturing" sector in real million of US Dollars (Source: our computation on OECD data)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Australia			6998,13	12194,74	10809,42	11580,37	15847,38	22751,58	23938,56	25408,13	24952,14	27431,70	33790,76	38293,15	36886,41	39697,38	31955,76	33520,56	37418,81	34421,68	27792,89	36337,56	52287,87	100732,20	35207,31	**720254,49**
Austria		2570,54	2195,94	2127,95	2769,63	2852,33	3650,58	3293,42			4465,94	5029,13	5274,42	5315,10	6552,32	6471,99	5402,04	5746,21	7272,64	8314,02	8503,29	11431,85	11356,28	12653,78		**123249,39**
Belgium																										
Canada		37704,32	42971,58	40619,01	42362,50	46579,94	53429,63	61219,75	66779,32	68117,43	26587,12	42102,01	42352,59	44016,82	49296,45	49134,95	51251,92	54420,73	63864,17	92561,41		93066,93	110105,90	109986,49	114176,71	**1402707,70**
Czech Republic																	5397,11	6854,31	6924,23	8257,46	9978,55	13321,41	17898,08	21055,51	20261,91	**109948,58**
Denmark											3078,42			3653,15				4339,13	3621,84	4400,91	4964,89	6321,78	7021,55	13176,02	12509,07	**63086,75**
Finland									2172,35	2533,93	2218,30	2218,86	2651,95	4592,44	5214,68	5235,98	5806,43	8426,84	8455,32	9372,93	8125,24	11009,31	15899,50	17394,89	12595,65	**123924,61**
France									29470,05	39060,22	45233,68	51514,61	52113,93	59205,48	66940,82	66001,42	61079,50	69777,07	62232,92	60367,12	54374,48	75264,08	90920,51	115519,83		**999075,70**
Germany		28292,00	25353,16	21041,61	26238,82	33023,99	41541,37	34978,72	45759,97	53170,28	55490,14	47993,51	40262,89	42909,80	49029,61	80793,31	40869,09	48399,80	47881,49	48054,74	47592,79	62377,29	75940,85	86684,54		**1083679,78**
Greece																		4825,03	6906,59	5412,72	5151,79	5686,12	7445,10	8248,91		**43676,26**
Hungary												2710,58	3602,61	4034,27							9669,61	13809,08	18092,45			**51918,61**
Iceland								56,36	86,82	115,13	131,19	88,63	84,50	97,53	110,91	152,23	280,73	312,49	311,59	317,32	348,83	427,81	470,66	804,18	1708,32	**5905,24**
Ireland																										
Italy		6099,65	6208,27	9561,92	15999,81	21765,98	21206,17	25455,69	28841,21	27041,08	28392,47	22675,11	23021,27	24750,29	26526,99	28970,64	31948,47	40353,27	40292,64	45179,50	41275,94	46928,82	67764,86	78512,74		**708772,79**
Japan		4966,67	5766,15	5916,18	6677,14	7283,10	8920,27	11877,63	12910,13	14353,66	16077,65	17556,32	19135,23	20894,44											39751,98	**192086,55**
Korea Republic										2688,66	3011,18	3378,62	4678,98	3857,56	4310,22	5122,87	6627,26	9279,69	12321,12	15297,70	16047,55	16601,46	16852,83	17675,87	17503,54	**155255,10**
Luxembourg															2750,40	2756,39	2722,07	3066,25	2787,87	4451,61	4975,89	5795,65	5695,33	5314,11		**40315,57**
Mexico	15798,31	5528,57	7283,08	9136,76	7990,00	8569,01	10183,78	15115,79	15608,86	17309,76	19821,18	18631,03	20328,41	15954,44	20952,17	22222,34	36910,53	42680,52	49886,53	55432,88						**415343,96**
Netherlands				14524,32	19765,78	26829,47	34693,21	32172,28	37681,86	48782,32	49358,25	47645,30	41047,98	51785,99	53968,16	61217,13	57303,35	74934,95	69176,96	78166,65	90462,85	112890,01	135667,65	151473,02		**1289547,49**
New Zealand																										
Norway							1408,92	1381,82	1378,03	1589,77	1955,04	1891,47	1902,35	2093,44	2321,85	2409,40	2645,50	5113,89	5045,56	6551,74	6166,49	8937,08	9424,32	19121,79		**81338,45**
Poland														2008,89	4164,13	5489,26	5938,00	9111,98	11333,06	13209,60	14270,20	16653,11	19627,83	29816,88	29012,39	**160635,32**
Portugal															6977,35	6894,09	5838,22	6047,44	5360,52	5315,25	4359,90	5181,78	5661,35			**51635,89**
Slovak Republic																		1028,88	1285,56	2015,65	1909,70	2319,68				**8559,48**
Spain																										
Sweden						1858,94	3235,14	3846,79	4268,85	5350,61	9148,88	7507,52	7116,32	14295,47	20896,00	21676,17	25122,74	31787,81	47757,86							**203869,09**
Switzerland					2418,32	3683,85	4624,15	5578,16	5638,52	8931,45	8473,14	7979,51	4662,17	7164,96	8884,73	8024,32	11130,30	14307,21	11236,38	15348,94	14817,15	19092,21	27643,53			**189638,98**
Turkey																				9822,00	10077,45	8821,36	15390,57	14454,13	19067,26	**77632,76**
United Kingdom				26693,04			52316,01	55873,08	67248,09	89304,01	82964,45	68670,87	67756,48	68715,28	68353,32	70900,53	79641,79	101111,34	104434,29	104148,10	133062,82	135832,48	150839,15	169052,43		**1696917,57**
United States		69944,44	73330,77	76179,41	85120,00	101356,34	126844,59	161292,11	191074,68	186347,56	184841,18	182612,64	191076,14	235502,22	259486,96	291641,49	312621,05	386334,38	414709,18	480561,00	467131,37	438820,39	439057,55	445558,72	476214,16	**6277658,33**
Total OECD Countries	**15798,31**	**155106,19**	**170107,09**	**217994,95**	**220151,42**	**265383,33**	**377901,20**	**434893,15**	**532857,30**	**590104,00**	**566200,32**	**557637,44**	**560858,97**	**649140,72**	**693623,48**	**774811,89**	**780491,86**	**961779,78**	**1020517,14**	**1106980,91**	**981059,67**	**1146927,24**	**1301063,71**	**1417236,05**	**778008,29**	**16276634,42**

Tab. III.7

CO2 from fuel combustion in Manufacturing industries and Construction in Million tons (Mt) (Source: IEA estimations)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total	Pop. @ 2005	Emission p/capita @ 2005
Australia	44,68	43,27	37,95	39,50	41,72	41,51	42,35	44,75	45,95	45,98	46,12	45,73	46,86	48,67	49,51	49,75	51,12	51,73	51,83	52,56	52,04	40,19	40,75	43,29	46,50	**1144,31**	20310000	5,63422E-05
Austria	11,84	11,22	11,84	12,85	13,11	12,30	12,53	12,81	12,91	11,08	11,52	10,67	11,10	10,98	11,23	11,81	13,03	13,12	12,54	13,72	13,55	13,86	14,35	14,69	14,47	**313,13**	8292000	3,77629E-05
Belgium	30,86	30,38	27,39	30,18	30,01	29,22	28,27	29,28	30,64	33,01	33,89	32,10	29,99	36,24	35,08	35,70	38,32	39,70	41,00	44,03	44,40	37,65	38,63	37,00	34,63	**857,60**	10398000	8,24774E-05
Canada	93,97	82,63	80,21	86,10	86,30	85,30	88,36	92,22	92,46	85,41	83,91	82,86	83,83	87,08	88,73	92,62	93,33	89,88	91,64	94,35	87,28	88,75	93,40	96,64	101,17	**2228,43**	32271000	6,90536E-05
Czech Republic	65,05	68,43	67,94	68,20	69,21	69,48	71,31	69,54	64,81	46,27	36,65	39,59	32,71	27,41	29,05	28,22	27,41	24,92	21,73	25,58	24,27	22,53	22,67	23,46	23,37	**1069,81**	10192000	0,000104966
Denmark	6,79	6,14	5,61	6,26	6,45	6,70	6,22	5,96	5,51	5,50	5,91	5,78	5,70	5,75	5,98	5,92	5,83	5,66	5,71	5,39	5,58	5,19	5,23	5,34	5,15	**145,26**	5417000	2,68156E-05
Finland	15,04	15,22	14,49	14,82	13,30	14,18	15,32	14,67	15,98	14,54	14,79	14,91	14,28	15,69	12,44	12,23	12,35	13,86	13,18	11,88	11,66	12,89	13,33	12,64	12,30	**345,99**	5246000	6,59531E-05
France	101,32	91,83	89,74	90,77	91,03	83,45	84,41	82,12	81,66	80,07	83,92	82,34	78,34	77,62	80,98	82,94	82,76	80,62	77,37	77,11	82,40	77,56	80,33	77,06	72,22	**2069,97**	60991000	3,39389E-05
Germany	225,27	207,07	215,01	216,47	219,29	203,57	202,82	206,67	205,70	179,26	153,93	145,92	137,48	139,31	140,07	132,30	131,08	129,90	124,34	126,26	120,29	120,31	120,71	117,19	115,06	**4035,28**	82652000	4,88225E-05
Greece	9,24	9,23	9,58	9,91	9,72	9,77	10,13	10,62	10,85	10,39	9,96	9,34	9,05	8,93	9,67	10,36	10,52	10,73	9,51	10,55	10,64	10,28	10,24	9,44	9,41	**248,07**	11100000	2,23486E-05
Hungary	21,91	21,53	20,94	21,42	20,64	20,48	20,06	19,08	18,96	16,69	13,60	11,20	10,77	10,58	10,78	10,71	8,63	8,22	7,61	7,79	7,59	7,69	7,20	7,70	8,41	**340,19**	10086000	3,37289E-05
Iceland	0,42	0,40	0,46	0,57	0,57	0,57	0,52	0,55	0,53	0,54	0,47	0,46	0,47	0,54	0,51	0,62	0,63	0,61	0,57	0,74	0,76	0,80	0,75	0,82	0,77	**14,65**	296000	4,94932E-05
Ireland	6,11	5,54	5,45	5,89	5,94	5,65	6,47	5,75	5,98	4,74	4,84	4,50	4,63	4,90	4,90	4,68	5,13	5,08	5,22	5,97	6,03	5,69	5,08	5,10	5,16	**134,43**	4143000	3,24475E-05
Italy	86,78	81,66	78,37	80,38	78,19	74,34	77,76	80,01	83,62	83,93	79,79	78,12	74,75	77,31	77,87	76,71	79,60	79,30	78,83	80,84	80,92	79,57	84,56	82,36	80,43	**1996,00**	58646000	3,40347E-05
Japan	238,87	245,77	238,08	252,22	250,14	241,87	240,90	254,24	260,38	294,41	289,08	282,07	277,99	283,01	286,42	291,57	293,56	272,09	277,47	283,83	273,22	277,89	276,90	283,17	285,84	**6750,99**	127897000	5,27846E-05
Korea Republic	30,42	28,07	28,63	28,44	28,79	30,33	33,43	38,44	41,60	53,60	64,21	68,61	77,00	85,23	88,62	94,13	97,76	89,51	96,88	103,47	101,76	100,20	97,64	94,99	94,82	**1696,58**	47870000	3,54414E-05
Luxembourg	5,94	5,64	5,21	5,86	5,85	5,31	4,70	4,98	5,25	4,96	4,57	4,19	4,46	3,99	2,59	2,58	2,18	1,55	1,61	1,68	1,59	1,46	1,39	1,54	1,55	**90,63**	457000	0,000198315
Mexico	67,14	68,25	72,85	71,78	75,90	66,73	72,35	69,06	71,66	73,90	72,67	74,84	65,98	69,22	65,95	66,35	69,49	72,49	66,60	67,86	61,25	61,29	57,66	60,42	58,88	**1700,57**	104266000	1,63099E-05
Netherlands	36,87	32,45	34,88	37,82	35,27	35,07	36,93	36,00	34,38	34,09	36,32	35,39	35,87	35,67	33,39	31,86	34,03	32,53	31,89	35,49	34,83	34,48	37,72	37,90	40,38	**881,51**	16328000	5,39876E-05
New Zealand	4,64	4,70	4,57	5,40	5,46	5,32	5,75	6,76	6,36	5,29	5,25	5,34	5,39	5,77	5,96	6,55	6,65	6,43	6,51	6,93	6,73	6,96	5,93	5,44	4,60	**144,69**	4097000	3,53161E-05
Norway	10,05	9,22	8,75	9,51	9,52	9,46	8,71	8,30	7,81	6,93	5,70	5,44	5,48	6,41	6,95	7,14	6,71	7,01	7,05	8,06	7,95	7,04	7,86	8,06	7,23	**192,35**	4639000	4,14637E-05
Poland	61,75	57,39	58,03	60,91	59,97	62,59	61,66	60,83	57,53	47,27	41,72	38,68	50,18	51,16	65,61	69,98	66,54	58,13	49,61	50,66	44,38	40,80	40,56	41,62	37,77	**1335,33**	38196000	3,49599E-05
Portugal	7,53	7,96	7,58	8,04	8,18	7,82	8,16	9,19	9,57	9,74	9,76	9,36	8,85	9,61	9,62	10,16	10,84	12,04	12,45	12,68	11,72	11,76	10,53	10,14	9,49	**242,78**	10528000	2,30604E-05
Slovak Republic	17,37	16,13	16,73	18,09	17,87	16,82	17,32	17,49	19,36	18,49	16,71	14,84	11,36	11,43	10,20	11,23	11,01	9,97	9,19	9,94	9,92	10,48	10,18	9,67	9,54	**341,34**	5387000	6,33637E-05
Spain	52,91	46,71	48,20	45,17	44,81	43,38	42,34	46,22	46,49	45,47	47,01	44,58	42,54	46,82	49,43	45,20	51,29	52,46	48,13	54,81	59,06	58,20	64,80	66,28	64,68	**1256,99**	43397000	2,89649E-05
Sweden	16,79	15,00	13,68	13,50	13,64	13,20	12,87	12,30	11,66	12,79	12,09	14,03	14,92	15,51	15,67	16,19	15,08	15,02	14,95	14,35	13,24	13,85	13,21	13,21	11,90	**348,65**	9038000	3,8576E-05
Switzerland	9,14	7,72	9,78	8,70	8,93	8,13	6,99	6,28	6,09	5,92	5,93	6,02	5,63	5,96	6,11	6,07	6,07	5,97	6,97	6,27	6,63	6,21	6,48	6,52	6,47	**170,99**	7424000	2,30321E-05
Turkey	20,29	21,31	22,46	24,76	23,72	23,10	27,53	29,47	30,72	33,72	35,60	34,58	34,65	31,53	35,44	43,97	47,41	49,63	42,98	58,54	43,60	53,91	60,19	59,68	56,64	**945,43**	72970000	1,29564E-05
United Kingdom	104,83	102,12	96,65	92,80	93,74	90,91	91,86	93,70	87,06	83,53	84,43	77,53	78,61	79,57	76,01	74,14	73,32	71,49	69,85	69,82	72,24	67,73	67,34	64,47	64,73	**2028,48**	60245000	3,36705E-05
United States	927,84	782,84	714,18	775,17	765,69	748,71	755,60	784,52	736,07	697,83	665,67	599,92	619,03	630,99	586,18	595,50	630,24	613,09	601,44	660,16	651,70	640,59	641,81	672,77	627,31	**17124,85**	299846000	5,71122E-05
Total OECD Countries	**2331,66**	**2125,83**	**2045,24**	**2141,49**	**2132,96**	**2065,27**	**2093,63**	**2151,81**	**2107,55**	**2045,35**	**1976,02**	**1878,94**	**1877,90**	**1922,89**	**1900,95**	**1927,19**	**1981,92**	**1922,74**	**1884,66**	**2001,32**	**1947,23**	**1915,81**	**1937,43**	**1968,61**	**1910,88**	**50195,28**	1172625000	4,28059E-05

Tab. III.8

FDI inflow in the "transport, storage and communication" sector in real million of US Dollars (Source: our computation on OECD data)

	1981	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Total**
Australia												77,62	775,32	179,36	202,15	177,46	2181,01	287,19		1099,91	1374,29	3169,84	834,99	-1309,81	-55,28	**8994,06**
Austria																		2674,24	767,62	220,26	219,50	-557,22	326,12	-598,40	-41,79	**3010,32**
Belgium																						-141,82	5873,31	-2443,75	107,79	**3395,53**
Canada																										
Czech Republic													3,39	11,12	1467,35	195,77	1,06	365,48	200,79	254,63	809,15	4267,06	-2756,10	247,57	4389,80	**9457,06**
Denmark													15,43	67,78	281,83	183,11	255,03	4309,04	381,56	2141,94	1232,91	263,03	-380,11	-1583,24	1564,88	**8733,18**
Finland														4,68	-29,12	78,76	-7,31	-21,63	196,40	-131,79	174,73	4093,57	898,42	1007,59	1311,05	**7575,35**
France	22,45		17,36	1,68	4,77	-19,52	-29,24	-73,56	187,50	137,95	230,47	197,59	144,30	205,13	219,55	585,38	721,55	3055,28	-310,96	1708,60	4173,21	-871,05	1863,99	3109,40	386,05	**15667,87**
Germany												33,12	9,62	185,53	-314,02	-4515,88	975,40	1147,36	-148,96	16625,20	1408,34	5035,99	4289,62	682,74	615,93	**26030,00**
Greece																					2,38	10,67	315,36	86,87		**415,28**
Hungary																			274,41		408,51	-97,12	-23,72	693,64	755,50	**2011,23**
Iceland												1,24	0,19	3,05	8,34	-0,05	15,59	0,89	0,13	3,24	0,20	11,18	-5,02	-43,81	32,44	**27,59**
Ireland																							140,68	85,49	-270,57	**-44,40**
Italy												16,79	46,60	107,47	50,93	214,98	123,14	-315,39	804,58	2358,31	1099,28	529,77	-357,02	487,84		**5167,27**
Japan	1,69	1,59			25,71	66,20	83,78	55,26	88,61	40,24	147,06	77,01	79,55	41,11	75,11	30,31	32,19	182,25	2976,38	7015,67	6704,68	1354,91	505,32	5730,40	2620,37	**27935,39**
Korea Republic										6,34	3,29	3,45	-1,14	28,00	5,76	61,49	194,00	422,40	522,14	125,70	89,41	542,43	569,06	328,99	1010,62	**3911,94**
Luxembourg																										
Mexico	1,69	-15,87	38,46		24,29	2,82	8,11	6,58	326,58	157,32	303,53	2002,30	1214,77	1294,44	490,22	455,21	721,68	340,73	220,38	-2115,40	2575,60	681,11	1539,42	1093,00	1012,14	**12379,13**
Netherlands											113,90	324,19	233,75	172,79	672,32	283,65	875,11	1463,31	1640,70	8674,78	1261,71	-1810,72	-4056,22	-1734,79		**8114,47**
New Zealand																										
Norway														7,40	100,34	292,26	387,72	234,42	758,94	686,39	146,85	226,26	1082,09	391,65		**4314,31**
Poland														39,78	53,26	159,79	52,11	4,38	1871,33	3421,20	1026,67	-747,77	-153,40	1999,08	-409,03	**7317,39**
Portugal														26,18		95,79	645,25	81,25	220,10	380,35	288,28	474,70	629,34	32,59	-345,94	**2527,89**
Slovak Republic																				971,61	39,52	34,16	-17,71			**1027,59**
Spain													81,73	86,95	87,03	115,97	81,34	177,52	1462,39	14195,93	2100,21	2138,28	1448,35	-1675,52		**20300,16**
Sweden									40,26	-55,64	80,77	89,81	178,81	239,47	239,51	508,84	634,61	856,98	1437,24	1157,73	989,55	2915,92	761,07			**10074,95**
Switzerland													24,61	156,86	-30,34	70,57	-3,63	47,57	1257,94	2104,57	3589,68	-35,30	566,33	-191,92	1301,20	**8858,15**
Turkey												1,15	1,14					3,13	2,04	2,00	1598,04	0,97	1,89	585,32	2876,11	**5071,78**
United Kingdom													728,57	23,81	-413,44	16,60	891,42	4983,98	44514,30	46153,50	-4693,68	-7132,27	739,56	13095,83		**98908,18**
United States							124,32	607,89	-1427,85	721,95	52,94	85,06	1468,18	4448,89	755,43	7402,13	6144,21	-1893,75	88367,35	19655,00	43499,02	3078,64	749,06	-2567,89	2621,24	**173891,83**
Total OECD Countries	**25,84**	**-14,29**	**55,82**	**1,68**	**54,77**	**49,49**	**186,98**	**596,18**	**-784,90**	**1008,16**	**931,96**	**2909,34**	**5004,82**	**7329,81**	**3922,21**	**6412,12**	**14921,49**	**18406,60**	**147416,78**	**126709,32**	**70118,02**	**17435,21**	**15384,67**	**17508,88**	**19482,51**	**475073,49**

Tab. III.9

FDI stock in the "transport, storage and communication" sector in real million of US Dollars (Source: our computation on OECD data)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Australia												793,54	1408,62	1583,35	1549,92	2062,87	3308,99					12971,51	18734,21	18645,62	17162,61	**78221,24**
Austria						91,43	96,57	92,04			203,39	190,62	218,14	182,16	402,32	354,48	672,42	1891,46	1480,11	1651,64	1538,74	1057,86	954,40	856,00		**11933,80**
Belgium																										
Canada					1204,25	1239,64	2010,84	2329,87	2813,04																	**9597,64**
Czech Republic																	913,81	1385,20	2185,33	2433,01	2753,32	5088,86	2539,90	3261,95	6432,41	**26993,78**
Denmark											1475,55			941,10				8629,31	8954,79	5703,53	5153,38	4084,24	5247,35	6643,13	7475,05	**54307,44**
Finland														228,63	362,59	312,46	275,37	326,63	471,20	523,87	511,50	2587,13	3808,06	4791,09	5393,21	**19591,75**
France												716,09	963,41	1128,84	1444,92	1400,40	1510,50	2323,88	1892,34	3098,57	8310,14	9803,82	9573,78	13768,46		**55935,14**
Germany									725,45	910,13		1281,90	1035,49	1253,30	1785,72	2399,38	1411,51	1420,28	1723,20	3876,46	4366,75	16616,30	20197,28	17177,46		**76180,59**
Greece																		5327,33	3203,42	2530,96	2594,86	3246,76	4532,94	6178,51		**27614,78**
Hungary												90,79	648,60	661,37				4045,31	4898,11		2591,91	3045,28	3417,60			**19398,95**
Iceland														2,38		5,17	20,76	11,66	5,29	3,01	1,52	42,95	39,70	29,79	250,75	**412,97**
Ireland																										
Italy											0,00	0,00	0,00	0,00				2477,26	3154,29	5268,49	5406,17	6148,64	7060,40	10789,93		**40305,17**
Japan		22,22	21,54	22,06	47,14	112,68	191,89	242,11	321,52	350,00	484,71	550,57	625,00	652,22											9202,85	**12846,51**
Korea Republic										38,17	40,12	42,64	41,02	68,11	72,39	132,34	324,95	743,96	1250,92	1351,60	1414,41	1943,11	2457,17	2718,53	3632,92	**16272,36**
Luxembourg																										
Mexico	57,63	6,35	-12,31	-10,29	8,57	22,54	50,00	169,74	1168,35	1447,56	1911,76	5545,98	6197,73	6090,00	5790,22	6859,57	1638,95	2200,63	3413,06	2758,76						**45314,79**
Netherlands													1931,50	1971,74	2369,77	2629,99	4636,80	5959,89	9960,92	17235,65	14539,72	14819,25	14203,98	13347,33		**103606,55**
New Zealand																										
Norway														299,42	381,81	512,66	762,64	737,37	1060,95	1923,71	2249,71	2745,97	5667,42	7309,34		**23651,00**
Poland														130,00	186,96	293,19	267,79	290,63	2469,90	2747,00	4792,65	4823,59	4674,53	6022,02	6262,04	**32960,28**
Portugal															209,23	326,60	367,66	381,20	553,77	941,88	1019,42	1349,35	2349,48			**7498,59**
Slovak Republic																		86,77	99,44	630,28	704,30	794,08				**2314,87**
Spain																										
Sweden																										
Switzerland													127,50	278,74	283,43	185,68	156,23	412,59	1699,27	2280,75	3223,98	3168,57	4440,65			**16257,38**
Turkey																				2487,00	2525,49	2902,91	3474,53	6940,37	12437,17	**30767,47**
United Kingdom														2758,68	3103,37	3287,62	3466,02	13535,00	64941,35	81756,14	49157,18	39144,83	43651,07	66555,33		**371356,59**
United States											4260,00	4275,86	6217,05	7927,78	7460,87	17092,55	21812,63	24013,54	46761,22	112595,00	108700,98	54730,10	49937,74	44603,67	47464,60	**557853,59**
Total OECD Countries	**57,63**	**28,57**	**9,23**	**11,76**	**1259,97**	**1466,29**	**2349,30**	**2833,76**	**5028,36**	**2745,86**	**8375,53**	**13487,99**	**19414,05**	**26157,82**	**25403,54**	**37854,95**	**41547,01**	**76199,90**	**160178,87**	**251797,31**	**221556,13**	**191115,10**	**206962,18**	**229638,52**	**115713,61**	**1641193,23**

Tab. III.10

CO2 from fuel combustion in Transport in Million tons (Mt) (Source: IEA estimations)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total	Pop. @ 2005	Emission p/capita @ 2005
Australia	49,92	51,05	50,51	52,69	54,21	55,66	56,60	58,78	60,60	61,39	59,97	61,45	62,54	64,17	66,85	69,31	70,66	70,66	72,03	74,25	73,66	75,36	77,54	77,70	79,11	**1606,67**	20310000	7,91073E-05
Austria	11,04	10,96	11,45	11,16	11,27	11,68	11,89	12,61	13,03	12,67	13,91	13,86	13,89	13,91	14,05	15,31	14,48	16,28	15,64	16,66	17,65	19,18	20,80	21,36	22,03	**366,77**	8292000	4,42318E-05
Belgium	15,43	15,61	15,95	15,98	16,37	17,85	18,39	19,88	20,30	20,00	20,50	21,89	22,36	22,72	22,60	23,61	23,68	24,08	24,26	24,31	25,09	25,00	25,94	26,52	25,77	**534,09**	10398000	5,13647E-05
Canada	126,99	110,05	107,88	111,21	113,20	113,20	118,04	125,42	127,44	123,84	120,14	124,38	126,29	132,46	135,98	139,30	143,72	146,36	150,03	148,80	146,66	149,28	151,93	156,67	159,58	**3308,85**	32271000	0,000102533
Czech Republic	7,38	6,29	6,34	6,76	6,57	6,50	6,59	6,69	7,09	7,18	6,38	8,16	8,12	8,74	7,44	10,20	10,46	10,83	11,90	12,06	12,86	13,40	15,22	15,94	17,23	**236,33**	10192000	2,31878E-05
Denmark	8,67	8,76	8,70	9,25	10,72	11,17	10,98	10,99	11,29	10,25	10,85	10,80	11,08	11,52	11,64	11,76	11,89	11,93	11,98	11,79	11,79	11,99	12,45	12,86	13,10	**278,21**	5417000	5,13587E-05
Finland	8,35	8,55	8,74	9,00	9,40	9,98	10,69	10,84	11,44	11,60	11,28	11,24	11,01	11,45	11,24	10,97	11,58	11,73	12,09	11,99	12,20	12,44	12,64	12,95	13,06	**276,46**	5246000	5,26992E-05
France	89,63	90,24	91,08	92,65	92,45	96,76	99,98	106,07	108,74	112,51	115,81	118,33	119,51	120,49	121,35	121,10	123,56	129,75	129,44	132,98	136,05	135,39	133,29	133,40	131,76	**2882,32**	60991000	4,72581E-05
Germany	123,89	124,16	126,22	129,86	129,92	135,97	140,92	145,82	149,27	158,36	161,16	163,94	168,74	166,31	168,20	169,28	169,83	172,82	178,11	173,99	170,03	167,67	160,74	163,08	155,73	**3874,02**	82652000	4,68715E-05
Greece	9,69	9,86	10,78	11,32	11,68	11,93	12,31	13,44	14,23	15,09	15,83	16,23	16,44	16,53	16,64	17,09	17,69	19,28	19,47	18,94	19,67	19,90	20,86	21,27	21,67	**397,84**	11100000	3,58414E-05
Hungary	8,07	7,89	7,42	7,57	7,66	8,05	8,38	8,42	8,75	8,32	7,28	7,04	7,02	6,85	7,04	7,04	7,46	8,31	8,84	8,78	9,24	9,92	10,38	10,87	11,80	**208,40**	10086000	2,06623E-05
Iceland	0,56	0,48	0,48	0,52	0,49	0,52	0,57	0,59	0,59	0,62	0,63	0,63	0,63	0,65	0,60	0,67	0,58	0,61	0,62	0,62	0,63	0,63	0,63	0,66	0,66	**14,87**	296000	5,02365E-05
Ireland	4,59	4,36	4,15	4,07	4,48	4,43	4,27	4,38	4,66	4,91	5,09	5,49	5,51	5,75	5,86	6,90	7,26	8,60	9,52	10,26	10,72	10,91	11,08	11,73	12,53	**171,51**	4143000	4,13975E-05
Italy	70,56	73,17	73,43	76,45	79,21	82,20	87,40	90,28	93,62	95,91	97,61	102,75	104,74	104,29	106,56	107,21	109,01	112,10	112,97	113,12	114,98	117,25	118,00	120,17	119,10	**2482,09**	58646000	4,23233E-05
Japan	152,76	147,35	151,38	156,19	158,05	163,53	169,51	178,48	191,18	209,66	220,93	225,17	229,86	241,75	249,20	254,75	256,56	255,68	257,68	256,57	259,01	254,16	252,16	252,64	247,82	**5392,03**	127897000	4,21592E-05
Korea Republic	11,00	12,47	15,96	17,55	19,02	22,14	26,62	30,45	34,70	43,27	48,49	53,95	60,84	68,89	78,12	84,78	86,41	74,56	81,44	87,89	90,48	95,71	97,96	97,71	86,22	**1426,63**	47870000	2,98022E-05
Luxembourg	1,42	1,43	1,40	1,43	1,54	1,60	1,79	1,87	2,19	2,60	3,12	3,41	3,44	3,49	3,32	3,41	3,62	3,79	4,13	4,66	4,91	5,26	5,84	6,51	6,90	**83,08**	457000	0,000181794
Mexico	74,70	74,48	66,40	69,66	70,22	69,43	71,23	72,55	79,80	85,84	92,25	93,67	97,32	99,08	95,29	92,65	94,52	97,49	97,04	102,19	103,83	107,44	114,09	123,06	130,11	**2274,34**	104266000	2,18129E-05
Netherlands	22,42	21,44	21,98	22,37	22,31	23,19	23,38	24,32	25,47	25,87	25,97	27,04	27,55	28,06	28,79	29,57	29,85	30,65	31,75	32,22	32,60	33,26	33,73	34,18	34,03	**692,00**	16328000	4,23812E-05
New Zealand	6,59	6,67	6,72	7,08	7,18	7,44	7,67	8,18	8,68	8,59	8,59	9,00	9,32	10,01	10,68	10,86	11,17	11,37	11,69	12,24	12,33	13,17	13,77	14,13	14,12	**247,25**	4097000	6,0349E-05
Norway	8,07	8,19	8,42	8,77	9,15	9,94	10,10	10,27	10,45	10,83	10,05	10,30	10,89	10,73	11,40	11,92	12,12	12,55	12,75	11,93	12,13	12,13	12,96	13,42	13,56	**273,03**	4639000	5,88554E-05
Poland	25,73	23,62	24,91	24,65	23,92	24,61	24,93	23,91	23,66	20,49	20,90	21,28	20,68	21,33	22,13	25,16	26,62	28,26	31,36	27,07	26,94	25,90	28,28	32,05	34,43	**632,82**	38196000	1,65677E-05
Portugal	7,01	7,46	7,28	7,08	6,66	7,11	7,78	8,54	9,05	9,68	10,43	11,29	11,77	12,38	13,02	13,89	14,32	15,69	16,52	17,86	17,93	18,46	19,43	19,84	19,06	**309,54**	10528000	2,94016E-05
Slovak Republic	4,21	3,90	3,22	3,31	3,31	3,42	3,54	3,68	3,74	4,04	3,36	3,51	2,91	3,32	3,76	3,48	4,06	4,13	4,20	4,02	5,30	6,09	5,58	5,88	6,45	**102,42**	5387000	1,90124E-05
Spain	42,13	42,44	42,83	44,41	43,95	45,21	47,82	56,77	60,03	62,94	65,43	68,94	67,90	70,22	71,44	76,40	76,36	83,78	88,04	89,91	93,98	95,69	100,59	104,97	108,69	**1750,87**	43397000	4,03454E-05
Sweden	16,35	16,45	16,77	17,60	18,15	19,33	19,65	20,73	21,28	19,77	19,45	20,21	19,33	20,08	20,23	20,03	20,32	20,62	21,12	21,27	21,22	21,45	21,70	22,16	22,49	**497,76**	9038000	5,50741E-05
Switzerland	10,57	10,82	11,29	11,54	11,65	12,30	12,54	13,23	13,55	14,40	14,82	15,17	14,16	14,51	14,27	14,28	14,74	14,88	14,86	16,42	16,11	16,07	16,21	16,31	16,39	**351,09**	7424000	4,72912E-05
Turkey	16,67	17,85	18,68	18,86	19,53	22,04	25,04	25,47	25,87	27,76	26,49	27,03	32,19	31,27	35,13	36,94	34,37	31,71	33,34	34,80	33,28	35,12	35,17	35,91	37,19	**717,71**	72970000	9,83569E-06
United Kingdom	86,13	88,12	90,58	94,94	96,09	102,14	105,94	112,77	118,01	118,06	116,44	117,73	119,12	119,28	118,17	122,56	123,35	122,45	125,85	123,85	122,96	124,47	125,94	127,38	128,68	**2851,01**	60245000	4,73236E-05
United States	1229,25	1220,35	1236,68	1274,28	1284,63	1308,27	1353,06	1414,68	1426,35	1419,98	1392,52	1423,24	1446,71	1499,20	1529,50	1568,22	1593,10	1631,25	1677,10	1708,06	1709,80	1738,39	1761,18	1783,65	1806,01	**37435,46**	299846000	0,000124849
Total OECD Countries	**2249,78**	**2224,47**	**2247,63**	**2318,21**	**2342,99**	**2407,60**	**2497,61**	**2620,11**	**2685,06**	**2726,43**	**2725,68**	**2797,13**	**2851,87**	**2939,44**	**3000,50**	**3078,65**	**3123,35**	**3182,20**	**3265,77**	**3309,51**	**3324,04**	**3371,09**	**3416,09**	**3474,98**	**3495,28**	**71675,47**	1172625000	6,11239E-05

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CHAPTER IV

Discussion remarks
of the main results and policy implications

4.1. Introduction.

By referring to the previous chapter, here we recall and deepen some reflections already made in relation to those results strictly associated to the main argument of our research. More precisely, in this chapter we focus our discussion on those findings related to the induced-FDI (technique, scale and cumulative) effects on the pollutants we have considered in our analyses and put aside the consideration of those results achieved for the other variables considered in our models (e.g. economic growth, market openness, protected areas, etc.[118]. In addition, the effect FDI generates on the considered pollutants through GDP and the composition effect[119] observed in the estimations of our models are also subject of consideration in these pages.

To make for easier reading, the following table (tab. 4.1) gives a synthetic view of these mentioned results. Finally, a discussion of some possible policy implications arising from the results of our analyses is given. In doing so, a reference to some aspects of the European Union environmental policies in our considered sectors will be made[120], although here it is not our intention to develop a detailed analysis of these policies. We do this by considering that the observed nearly-zero impacts that FDI generates on our pollutants might be seen as a result

[118] For these, we invite the reader to refer back to the sections where the results and conclusions of the analysis devoted to each single sector are reported.

[119] It is worth highlighting that none of the variables used for the construction of the composition effect were associated to a FDI measure since when this was done the estimation results of other relevant variables in the models were badly affected in their statistical significance.

[120] The European Union is the area of our primary interest and the environment is one of the subjects of its major policies. Attention to environmental issues began in 1973 just after the UN Conference of 1972 which broadly highlighted the concerns reported in the "limits to growth" work of the Club of Rome. It must be underlined, however, that a final and specific recognition to environmental matters was given in Europe with the Treaty establishing the European Union in 1987. Nowadays, the majority of environmental policies implemented by the European member States have their origin in European law, although its enforcement occurs at national levels.

deriving from a mix of "forces". Some of these "forces" can be seen in the technique and scale effects, some others in the existence of a regulatory framework able to influence the nature and the modes in which economic activities must perform from an environmental point of view. As is known, the majority of European environmental regulations set minimum standards and leave to each single Member State the definition of how to reach them with the result that national environmental policies are quite restrictive (Scheuer, 2005).

Tab. 4.1 - The main results of the analyses.

"Agriculture and fishing" sector			
Model	**Type of effect**	**Coefficients**	**Computation at the sample mean values** (FDI, SCTRrel, GCF)
Model [1] with CH_4 as dependent variable	induced-FDI technique effect	+0.0427 *FDI*	-
	induced-FDI scale effect	+0.0018 *FDI*	-
	induced-FDI cumulative effect	+0.0427 + 0.0018 *FDI*	+0.0213
	composition effect	n.a. (in terms of sectoral relevance)	n.a.
	impact of FDI through GDP	-	-0.0003
Model [2] with CO_2 from sectoral fuel combustion as dependent variable	induced-FDI technique effect	-0.0848 *FDI*	-
	induced-FDI scale effect	-0.0036 *FDI*	-
	induced-FDI cumulative effect	*-0.0848 - 0.0036 FDI*	-0.0436
	composition effect	n.a. (in terms of sectoral relevance)	n.a.
	impact of FDI through GDP	n.a.	n.a
"Manufacturing" sector			
Model	**Type of effect**	**Coefficient**	**Computation at the sample mean values** (FDI, SCTRrel, GCF)
Model [3] with CO_2 from sectoral fuel combustion as dependent variable	induced-FDI technique effect	+0.0058 *FDI*	-
	induced-FDI scale effect	+0.0014 *FDI*	-
	induced-FDI cumulative effect	+0.0058 + 0.0014 *FDI*	+0.0051
	composition effect	-0.1360 *SCTRrel* (in terms of sectoral relevance)	-0.2352
	composition effect	+0.1667 *GCF* (in terms of capital-labour ratio)	+3.7794
	impact of FDI through GDP	-	+0.00002

"Transport, storage and communication" sector			
Model	**Type of effect**	**Coefficient**	**Computation at the sample mean values** (FDI, SCTRrel, GCF)
Model [4] with CO_2 from sectoral fuel combustion as dependent variable	induced-FDI technique effect	+0.0027 *FDI*	-
	induced-FDI scale effect	+0.0014 *FDI*	-
	induced-FDI cumulative effect	+0.0027 + 0.0014 *FDI*	+0.0022
	composition effect	n.a. (in terms of sectoral relevance)	n.a.
	composition effect	+0.0791 *GCF* (in terms of capital-labour ratio)	+1.7882
	impact of FDI through GDP	-	+0.0006

4.2. The "agriculture and fishing" sector: main results.

As already discussed, our analysis of the "agriculture and fishing" sector was conducted through two different equation models to mainly investigate the impact of the sectoral FDI inflow on two different pollutants (CH_4 and CO_2 from fuel combustion associated to the sectoral activities). The next two subsections will respectively refer to each of them.

4.2.1. Model [1]: the effect of FDI on CH_4.

In relation to the analysis carried out for CH_4 (which is considered one of the most significant pollutants associated with agricultural activities, especially to rice paddy cultivation, livestock and manure management), we observed two positive coefficients (+0.0427) for the technique effect and (+0.0018) for the scale effect respectively. The algebraic sum derived *0.0427 + 0.0018 LnFDI*, that is the consideration of the two effects just mentioned while considering FDI at its sample mean value, gave us a positive (+0.0213) cumulative or total effect of FDI on CH_4. We argued that the positively-signed technique effect we achieved – although quantitatively very low and almost insignificant – would prove that, at an initial stage, FDI inflowing in the considered sector exerts a detrimental impact on the environment of the receiving countries (this considered in terms of increase of CH_4 pollution).

In consideration of this first result, we are unable to support the mainstream view in literature. It refers to the existence of a negative relationship between investment and environmental quality and explains this as the result of a technological effect (implicitly associated to the FDI phenomenon) from which higher production efficiency levels and minor polluting emissions are generally expected (e.g. Liang, 2006). When the considered FDI measure was taken in squared terms and mathematically handled to retrieve the scale effects, we still observed a positively-signed coefficient. The positive sign of the scale effect – even in this case, quantitatively very low – allows us to observe how the detrimental impact of the sectoral inflow of FDI on the environment is confirmed – although with minor magnitude with respect to the technique effect – even when further growth of the FDI scale is considered. In fact, additional increases of FDI would lead to an increase of CH_4. The detrimental role of FDI to CH_4 was also observed from the result deriving from the computation of the cumulative effect. Here again, although quantitatively of very low significance, its positive sign induces us to say that the inflow of FDI would be to some extent harmful to the environment, since the FDI flow increases would generally result in a rise of CH_4 emissions.

As highlighted in the dedicated sections, this evidence confirms views expressed in that part of the literature which find positive FDI-pollutant relationships (e.g. Bao et Al., 2011; Shahbaz et Al., 2011; He, 2006) and contradicts others which produce counterfactual evidence (e.g. Kirkulak et Al., 2011). Our result can be commented on by saying that investment means more production, which in turn implies more consumption and a higher level of pollution. In particular, when this happens at a faster pace than its expected capability of bringing and implementing technological advances and higher production efficiency, the fact that investment is detrimental to the environment might very likely be the natural result. Apart from understanding the meaning of the algebraic signs associated to the relationships we found, our discussion cannot leave unconsidered the quantitative aspect of the estimated coefficients. As already said, the estimated coefficients of the technique, scale and cumulative effects are all characterized by such low numbers that they make them almost insignificant from a quantitative point of view.

This is also true when the identification of the impact of FDI on CH_4 through GDP is observed. Although the analysis shows a negative relationship (equal to -0.0003 if computed at the sample mean values of GDP and FDI), once again the quantitative consideration of the result makes us observe a number very close to zero. This suggests we should reconsider what has been said above. Despite the positive sign in the CH_4-FDI relationship (or the negative sign of the same relationship through GDP), what must be stressed is that the impact of FDI on the levels of the considered pollutant (either detrimental or beneficial) is quantitatively so low that we should more realistically talk about a situation of no impact at all or, even better, of nearly-zero impact.

In this sense, we should highlight the almost neutral role FDI plays on the considered environmental variable. The fact that foreign investment inflowing in the analysed sector of the considered countries brings in itself certain levels of technological development can surely remain a possible reason to explain such evidence. In addition, another possible reason could be seen in the fact that the technological advance brought by FDI is induced by the existence of an environmental regulatory framework in receiving countries. As will be reported, in fact, in the last section of this chapter, where the policy implications of our analysis results will be referred, the agriculture and fishing sector of the majority of the OECD countries is already characterized by the existence of environmental regulations.

As already noted in the conclusions of the section dedicated to the analysis of this sector, some further analyses of the pattern followed by the sectoral flow of investment in the considered countries and over the considered period would be desirable. In fact, this could help us to understand better whether this situation of nearly-zero impact of FDI on CH_4 is the result of the fact that investment has moved away from more polluting sectoral practices in terms of CH_4 (e.g. the running of livestock activities) to approach other less polluting activities (e.g. the running of rural tourism activities)[121].

4.2.2. Model [1]: the composition effect on CH_4.

The composition effect was considered in terms of sectoral relevance and, more specifically, in terms of the ratio between the sectoral GDP and total GDP. Our analysis did not produce any evidence of statistical significance and, therefore, no valid comment can be made.

4.2.3. Model [2]: the effect of FDI on CO_2.

With regard to the other model used to investigate the "agriculture and fishing" sector and to observe whether and how the sectoral inflow of FDI impacts the emission level of CO_2 from the sectoral fuel combustion, we observed two negative coefficients: -0.0848 for the technique effect and -0.0036 for the scale effect. The consideration of these two together -0.0848 - 0.0036 *LnFDI* gave us the possibility of also observing a negatively-signed cumulative effect (-0.0436). Broadly speaking, these findings would help us to prove that the flow of FDI entering our considered countries exerts a beneficial effect on the level of CO_2 emissions from sectoral fuel combustion. In fact, the level of CO_2 would initially decrease in response to an increase of FDI as a result of the technique effect which assumes - as already said above - an environmental amelioration due to technological advances implicitly associated to the investment dynamic.

The decrease of CO_2 as a result of FDI increases is also observed through the scale effect (although with minor magnitude with respect to what is observed for the technique effect) and the cumulative effect of our investigated relationship. It is the case to highlight that, in this specific case of analysis, we are unable to compare what has just been said with the result associated to the identification of

[121] As already referred in the specific section – although the investigation of this aspect goes well beyond our analysis purpose – there are no documents which, to the best of our knowledge, can support us in this sense. Neither the World Investment Reports published by the United Nations Conference on Trade and Development (UNCTAD) nor a search for other works in the specific literature helps us in bridging this lack of information.

the impact FDI generates on our considered pollutant through GDP. This cannot be made the subject of any reflection since the GDP variables in our empirical work were both found to be statistically insignificant.

As has already been said in the appropriate section, our findings agree with those works which have commented on the beneficial role of FDI on CO_2 because of the existence of a negative relationship between them. In this sense, for example, Yanchun (2010) finds evidence of the existence of a virtuous circle between FDI and pollution levels while specifically investigating the Chinese inflow of FDI over the period 1978-2008 through a time series regression analysis. More specifically, this result is seen as the natural expectation of a process where FDI activated by a MNE in a host country unavoidably generates technology spillover in domestic firms[122]. These firms, in fact, should feel an incentive to adopt more modern technologies to improve their productivity – and also their environmental performance – to enter or stay in its market network (Johnson, 2006; OECD, 2002). A different view is instead expressed in those analyses where a counterfactual evidence has been observed. Some studies find a positive relationship between the inflow of FDI in the primary sector and CO_2 emissions. In this sense, for example, Jorgenson (2007), although his analysis focuses on less developed countries and the amount of CO_2 emissions level he uses is different from that employed in our investigation[123].

Even for the case of this investigation, and apart from the debate still open in literature, what we hope to highlight is the need to go beyond the observation of the algebraic signs of the coefficients achieved in the analysis. In fact, the consideration of their quantitative aspect should induce us to speak in terms of the nearly-zero impact FDI generates on the level of our considered pollutant. As a consequence, we should more appropriately discuss the almost neutral role FDI plays on the environmental feature we have considered.

[122] It is the case to recall that technology transfer can happen through four main channels: 1) vertical linkages with suppliers and purchasers in the host country; 2) horizontal linkages with competing or complementary companies in the same industry; 3) migration of skilled labour force; 4) internationalization of research and development activities (OECD, 2002).

[123] In Jorgenson's work CO_2 was considered as the amount of emissions coming from agricultural production as a whole. We have used, instead, data associated to the amount of CO_2 generated in the "agriculture and fishing" sector as a result of fuel combustion activity.

Once again, as already pointed out, an investigation in the pattern of the sectoral inflow of investment could help to better identify whether this nearly-zero impact of FDI on CO_2 can be ascribed to the fact that investment has moved away from more polluting sectoral practices to approach other less polluting activities.

4.2.4. Model [2]: the composition effect on CO_2.

Even for this case of analysis, the result achieved from our analysis in relation to the composition effect (considered as before in terms of sectoral relevance) were not statistically significant. As a result, we find ourselves unable to make any comment on it.

4.3. The “manufacturing” sector: main results.

4.3.1. The effect of FDI on CO_2.

The model estimation, used for our investigation of the relationship between the inflow of FDI and the emission of CO_2 from fuel combustion in the "manufacturing" sector, produced useful evidence in allowing us to comment on the induced-FDI technique, scale and cumulative effects. The outcomes associated to the technique and scale effects showed both positive coefficients equal to +0.0058 and +0.0014 respectively. As a result, the cumulative effect, achieved from 0.0058 + 0.0014 *FDI*, is also positively-signed and equal to +0.0051 (if computed at the sample mean of FDI). Broadly speaking, it would be proof of the detrimental role FDI plays on CO_2 levels in the considered sector and also of the fact that the effect deriving from technological advances implicitly associated to FDI does not hold. This detrimental role of FDI is also confirmed by the analysis of the impact FDI generates on CO_2 through GDP, whose result has been computed in about +0.00002 Mt. of CO_2 (in natural logarithmic terms) while considering FDI and GDP at their sample mean values.

In this sense, our result disagrees with the evidence detailed in other works which have found FDI plays a beneficial role in reducing air pollution and whose analyses have been appropriately recalled in the concluding part of the dedicated section. They justify this FDI-pollution inverse relationship by referring to the fact that the FDI flow implicitly brings with it some levels of technological advances from which beneficial environmental effects are generated. (e.g. Kirkulak et Al., 2011; Acharyya, 2009).

The evidence we have achieved, instead, supports those other studies where technique effects between FDI and pollution have been positively-signed (e.g. Shahbaz et Al., 2011; He, 2006). As has already been remarked in the devoted section, this would imply that technology improvements implicitly associated to investment do not always reduce the negative environmental impact. Furthermore, in relation to the scale effects, our evidence agrees with those views expressed in the literature which state that they are normally expected to be detrimental to the environment (e.g. O'Connor, 2000).

However, similarly to what has been done before, we feel it is necessary to highlight the very low quantitative relevance of the result achieved from our estimation analysis. In this sense, our finding can be broadly commented on in terms of the trivial detrimental role FDI exerts on the considered environmental variable. In fact, apart from the algebraic sign, our evidence induces us to speak in terms of a nearly-zero impact of FDI on CO_2, namely of an almost neutral role FDI plays on the considered pollutant. This should make us reconsider what was said above and believe that the environmental amelioration resulting from technological advances generally thought to be embedded in FDI can still represent a valid reason to explain the nearly-zero impact we have observed. Having said this, and similarly to what was highlighted in the previous sections, we do believe the development of a qualitative examination of the sectoral inflow of FDI entering the OECD countries to be valuable. This might help to better understand whether the observed almost neutral role of FDI on CO_2 is the result of an investment relocation phenomenon whose dynamic attracts a major quota into "less dirty industries" while pushing investment away from "dirtier industries" (i.e. Mani & Jah, 2006). As we have already said, the search for this aspect is beyond the purpose of our work. Nevertheless, this can certainly remain in the research agenda for future work.

4.3.2. The composition effect on CO_2.

The consideration of the composition effect in our analysis was twofold. First, it was considered in terms of the capital-labour ratio (actually measured by the ratio between the Gross Capital Formation - GCF - and the total number of work force) to refer to a broad concept of composition of the economy of our considered countries. Secondly, it was also considered in terms of the relevance of the manufacturing sector in the whole economy and measured as the ratio between the sectoral GDP and the total.

With regard to the first considered aspect of the composition effect, our analysis has shown a positive coefficient (+0.1667) characterizing the correlation between CO_2 and GCF from which an actual impact of about 3.78 Mt. of CO_2 (in natural logarithmic terms) can be computed if we take GCF at its sample mean value. As has already been said in the devoted section, its interpretation induces us to say that the more the degree of capitalization of our considered economies increases, the more the detrimental impact on CO_2 is.

Our finding seems counterintuitive with respect to the generally accepted view which is based on the conviction that capital accumulation brings technological advances which in turn generate beneficial effects on the environment. However, as we have already remarked, we should think that this cannot always be seen as the rule of thumb. Technological progress can certainly contribute to abate pollution, but the effectiveness of its role actually depends on the speed of capital accumulation. If capital accumulation proceeds at a faster pace than the actual implementation of technological innovation, then the possibility that it can help to solve pollution problems is highly unlikely.

The evidence we have achieved agrees with those works which have found that the rise of fixed assets (plants and machinery, vehicles, buildings, etc.) results in higher pollution levels as a consequence of higher production levels and more consumption (e.g. Mazzanti et Al., 2007; He, 2006; Cole & Elliott, 2005; 2003; Antweiler et Al., 2001). Antweiler et Al. (2001), for example, postulate a Factor Endowment Hypothesis (FEH) and investigate the environmental impact deriving from trade liberalization. They find evidence that a growth in the capital-labour ratio of a country generates an increase of SO_2 pollution while the contrary is observed for those countries characterized by capital scarcity. Other authors replicate this analysis and take into consideration other pollutants such as CO_2, NO_X and Biological Oxygen Demand (BOD). The evidence achieved shows the existence of statistically significant positive correlations, which confirm that the higher the capital to labour ratio is, the higher the pollution intensity is (Cole & Elliot, 2003).

Before moving onto commenting the result of the other variable we have considered for the composition effect, it is worth highlighting how the very small number characterizing the coefficient of this version of the composition effect induces us to talk about the quantitative irrelevance of its impact on our considered pollutant.

With regard to the other version of the composition effect in our model, considered in terms of relevance of the "manufacturing" sector in the whole economy, the estimation results we have achieved show a negative coefficient (-0.1360) characterizing its relationship with CO_2. It allows us to compute an actual impact equal to about -0.2352 Mt. of CO_2 (in natural logarithmic terms) if the sectoral relevance measure is considered at its sample mean value. This would highlight the beneficial role the manufacturing sector plays in reducing CO_2 emission which, according to a generally accepted view, is explained through the fact that investment (and free trade) promotes comparative advantages among nations, inducing them towards an efficient specialization of their economic systems (OECD, 2001).

In other words, our result would induce us to say that the "manufacturing" sector we have analysed is characterized by comparative advantages, which make our considered countries' economies cleaner (in terms of CO_2) the more specialized they are in it. More specifically, specialization would be due to the sectoral efficiency in resource allocation which makes production achievable by employing lower inputs per unit of output and is less polluting as a result. This finding agrees with that part of the literature which refers to the existence of the beneficial result of the composition effects (or structural effect) on the environment, although the opposite view is also referred, as has been reported above when commenting on the result achieved for the composition effect.

An explanation of these contradictory views is given by a work we have already referred to. In their analysis of 2003, Cole and Elliot highlight how the actual impact of the composition effect on the environment depends on a given country's comparative advantages, which could lead to different types of economic specialization and to diverse forms of environmental impact (either positive or negative) as a result. To clarify this, it must be considered that trade and investment liberalization unavoidably change the production-mix of a country towards those products where it has a comparative advantage. This implies the implementation of a resources reallocation process within the considered country through which trade and investments improve their economic efficiency. However, the environmental effect will exclusively depend on the type of sectors in which the country builds its comparative advantage. If the expanding sectors are less energy intensive than the contracting ones then beneficial results will be observed on the environment and vice versa.

As an additional consideration, it could be observed how the achieved result could seem counterintuitive with what has been said in relation to the induced-FDI technique, scale and cumulative effects. It is not so, if we consider that the GDP measures used to construct the sectoral relevance variable make us look at a bigger picture with respect to what we observe when specifically considering FDI. In fact, the sectoral economic performance expressed in the sectoral GDP is made by a variegated set of activities generating CO_2 emissions from fuel combustion, which are not all evidently linked to or captured by the FDI sectoral inflow.

Having said this, even in this case, what should be stressed is the very small number characterizing the composition effect of the manufacturing sector on the considered emission of CO_2. By taking into account the quantitative irrelevance of the coefficient, once again we should talk in terms of the almost neutral impact this sector generates on the CO_2 level.

4.4. The "transport and communication" sector: main results.

4.4.1. The effect of FDI on CO_2.

The empirical analysis on the relationship between the FDI inflowing in the "transport and communication" sector and the emission level of CO_2 from the sectoral fuel combustion allowed us to observe a coefficient equal to about +0.0027 for the technique effect and another equal to about +0.0014 for the scale effect. This would prove that at a first stage the sectoral inflow of FDI impacts negatively on the environment (this intended in terms of CO_2 from sectoral fuel combustion) and that the same happens - although with minor magnitude - once the investment flow reaches and overtakes certain thresholds. Due to these two negatively-signed effects, the cumulative effect cannot be anything else than detrimental to the environment, being characterized by an actual impact computed as equal to +0.0022 (Mt. of CO_2 in natural logarithmic terms) if we consider FDI at its sample mean value.

As more extensively commented in the dedicated section, our evidence agrees with the outcomes produced in other works, which find positive correlations while considering different sets of pollutants (e.g. Bao et Al., 2011; Shahbaz et Al., 2011; He, 2006). However, there are other studies – also belonging to the mainstream literature – which have found an inverse relationship between FDI flows and environmental pollution and to which our findings disagree. These have stressed the beneficial role FDI exerts on the environment of receiving countries and have explained this by referring to the ability FDI has in bringing technological advances, higher production efficiency levels and minor polluting emissions as a result (e.g. Gonzales-Perez et Al., 2011; Kirkulak et Al., 2011; Acharyya, 2009; Liang, 2006).

However, apart from the debate in the literature and going beyond the consideration of the algebraic signs characterizing the coefficients we have achieved, it is important to highlight the very small numbers they are characterized by. In consideration of this, in fact, we should be induced to refer to our results in terms of a nearly-zero and, therefore, the almost neutral impact of the sectoral inflow of FDI on the considered type of CO_2. Once again, similarly to what has previously been said, it would be relevant to investigate the sectoral inflow of FDI from a qualitative point of view since this could contribute to a better understanding of whether this environmentally slightly negative – or neutral – role of FDI is the result of a relocation mechanism which attracts a major investment into “less dirty" transport and logistics practices while making it move away from “dirtier" ones. As has already been highlighted in the previous cases, this was not the purpose of our study although future research could be useful.

4.4.2. The composition effect on CO_2.

With regard to the composition effect, we observed that the estimation of the considered model did not generate any useful evidence in relation to the variable expressing the sectoral relevance. Instead, the relationship between the capitalization level (considered in terms of GCF-labour ratio) of the considered OECD economies and CO_2 emissions was found statistically significant and characterized by a coefficient equal to about +0.0791. As already commented above in relation to the other case of analysis, this outcome makes us state that the composition effect is detrimental to the environment since an increase in the capitalization level results in an increase of the considered type of CO_2 emissions.

In other words, we could say that those economies more materially capitalized (in terms of fixed assets such as plants and machinery, equipment, vehicles, land improvements and buildings) appear to be more polluting. As already highlighted, our result goes against a widely accepted view that capital accumulation implicitly brings with it levels of technological advance. However, it goes along with another generally accepted perception which explains the positive sign of the considered relationship through the fact that the increase and accumulation of fixed assets (plants and machinery, vehicles, buildings, etc.) results in higher production levels, which means greater consumption and, in turn, more pollution. Put in these terms, our result confirms that achieved by other works and agrees with the concept that technological progress can certainly play a role in reducing pollution, but whether this is completely true depends on the speed of capital accumulation (e.g. Mazzanti et Al., 2007; He, 2006; Cole & Elliott, 2005; 2003; Antweiler et Al., 2001). Of course, if capital accumulation proceeds at a faster pace than the implementation of technological advances, then the earlier is unable to guarantee the reduction of pollution and to play a beneficial role on the environment.

Having said this, it is relevant to highlight the quantitative aspect of the coefficient under consideration. As can be observed, it is characterized by a very small number which would make us observe a situation of a nearly-zero impact of capital accumulation on the considered pollutant rather than one which is really detrimental to the environment.

4.5. Implications for policy decisions.

Remarking on the main results of our analyses helps us to develop considerations and reflections from which some useful suggestions for policy making might be derived. Although very briefly, the policy implications arising from our work have already been referred to in the concluding parts of the sections devoted to our empirical analyses where the estimation results were discussed. In the next subsections we highlight the policy suggestions identified in the previous chapter for each sector and - for what has been noted in the introduction of this chapter - attempt to contextualize them within the policy scenario existing in the area of our primary interest, that is the European Union.

4.5.1. Policy implications for the "agriculture and fishing" sector.

With regard to the results achieved from model [1], where the "agriculture and fishing" sector was analysed while considering CH_4 as the dependent variable, we have basically observed a nearly-zero impact of FDI on the environment. The extremely low coefficient of the cumulative effect of FDI on the considered pollutant (although positively-signed) shows this in all its evidence. This result is explained by referring to the major technology efficiency implicitly brought in by FDI which might be generated by the environmental regulation context characterizing the sector. In fact, the ability of the sector to promote and attract more or less significant quotas of "environmentally-friendly" investment might also be the consequence of the fact that the OECD area is strongly characterized by the existence of environmental regulation frameworks.

We have noted that, particularly in the last three decades, the issue of the relationship between agriculture and the environment has been put on the agenda of the majority of OECD countries for their agricultural policies decision. These have imposed and still impose regulatory requirements (which can vary from outright prohibition to standards and resource-use limits) at state, regional and local level with the aim of preventing and/or limiting environmental degradation occurring from bad agricultural practices (OECD, 2008; 2003)[124]. By making closer reference to the European case, for example, the 1992 Common Agricultural Policy reforms generated - among other things - a significant impact on a number of parameters characterizing CH_4 emissions from enteric fermentation and manure management. The implementation of this policy, in fact, has brought a significant change in the type and number of livestock. In addition, a change has occurred in the enhancement of the trend of livestock productivity (Bates, 2001).

From what has been observed, considerations for policy decision should induce us to favour those proposals which aim to enforce the sectoral inflow of investment as having potential, and very low impact on the considered environmental variable because they are conditioned by the existing regulations. The existence of strong and well-enforced environmental policies surely represents a barrier to the entrance of environmentally-damaging investment and an attraction for sustainable investment run by more responsible operators through whom a more sustainable use of natural resources can be pursued. An additional consideration might refer to a policy oriented to the pricing of environmental

[124] During the 1990's European countries and the United States, for example, widely used incentive payments to support the use of less intensive farming practices, land retirement payments tailored to specific environmental objectives, and transitional payments to assist farmers in implementing structural changes beneficial to the environment. Other countries such as Australia, Canada and New Zealand, instead, widely recurred to the use of community-based approaches (i.e. supporting collective action through the organization of land-care groups or conservation clubs), which rely on the farmers' self-interest in environmental conservation and make use of local expertise to solve environmental problems.

goods and externalities which can represent a mechanism to ensure the orientation of investment activities towards an efficient path so avoiding their shift towards environmentally-damaging sectors and/or damaging activities within the same sector (OECD, 2001).

The analysis of model [2], which investigated the "agriculture and fishing" sector on the basis of the relationship between FDI and CO_2 from the sectoral fuel combustion, made us note an inverse correlation and showed the positive role the sectoral inflow of FDI plays on the considered environmental feature: its increase would generate a decrease of CO_2. Apart from the algebraic sign of the investigated relationship, we also noted how it is characterized by a very small number which might be perceived as irrelevant from a quantitative point of view.

Considering the result we have achieved, the policy suggestion could convincingly go along with - given the existing regulatory frameworks - the indication of enforcing the sectoral inflow of FDI (and trade liberalization with it). It is very likely, in fact, that FDI is characterized by levels of technological innovation which make possible the very slightly beneficial and almost neutral role it exerts on the CO_2 emission level from the sectoral fuel combustion.

4.5.2. Policy implications for the "manufacturing " sector.

The investigation of the relationship between the sectoral inflow of FDI and CO_2 from the sectoral fuel combustion made us observe the existence of positively-signed coefficients characterizing its technique, scale and cumulative effects. As commented in the devoted section, these results would show the detrimental impact FDI exerts on CO_2 emission levels. However, it was also observed that these effects were quantitatively characterized by such small numbers that we are induced to speak in terms of nearly-zero impact of FDI on the environmental variable under consideration. These quantitatively very small coefficients characterizing the mentioned relationship - although positively-signed - would justify our support to those policy proposals aimed at increasing the investment level in the sector. In fact, the very low detrimental and almost nearly-zero impact FDI plays on the considered environmental variable makes the enforcement of sectoral investment a practicable option. It can be said that the very low detrimental impact FDI generates could be faced by implementing some operational principles of environmental economics. More specifically, the adoption of mechanisms through which pricing environmental goods and externalities can drive investment activities along efficient paths and avoid their shift towards environmentally-damaging sectors and/or activities within the same sector (OECD, 2001).

The implementation of a policy approach aimed at enforcing investment in the sector would also be justified if the result of the composition effect (observed in terms of sectoral relevance) is considered. Its negative coefficient - although quantitatively low - represents the existence of a virtuous circle between the relevance of the manufacturing sector and the levels of CO_2. This would highlight that there is no evident reason to avoid the sector gaining more relevance over the total economy and encouraging the entrance of investment in this specific sector of our considered economies. At the end of the day, here we are considering a sector which has been the subject of environmental policy attention for a long time, namely since the sustainable use of resources became one of the most prominent issues on the international political agenda[125].

In fact, we could realistically explain the very small coefficients found in our empirical analysis by recognizing the role that various regulatory frameworks have exerted on the environmental performance of the sector. Without entering into a detailed identification of the various policies implemented, which is not the purpose of our work, we could observe how over the past decades the policies dedicated to the manufacturing sector adopted by the majority of industrialized countries have basically relied on the so-called "end-of-pipe" measures. For example, European countries have particularly focused on measures such as cleaning wastewater and air, energy efficiency, recycling and material optimization (Greenovate Europe, 2012).

If we consider the result associated to the variable representing the second aspect of the composition effect in our analysis (namely, the capital-labour ratio)

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[125] This political agenda has been particularly characterized by the identification and implementation of environmental policies and tools primarily focusing on compliance with emissions, energy efficiency and waste reduction.

it would suggest a different policy approach. The positive sign of its coefficient would support the adoption of policies against the growth of FDI. In fact, capital accumulation is also determined by the entry of FDI into an economy and the positively-signed coefficient we have achieved in our analysis indicate that its increase would generate a growth of the considered pollution level. In such a context, the implementation of a policy approach based on the already mentioned principles of environmental economics could represent a step in the right direction. However, apart from the algebraic sign, the quantitative aspect characterizing our coefficient makes us observe such a small number that we note the almost irrelevant impact the composition effect exerts on the level of CO_2. This might still suggest the implementation of policy prescriptions based on the environmental economics principles as said before, although a more lax approach could be appropriate (OECD, 2001). Apart from this, however, there is no reason to make a call for the reduction of FDI.

4.5.3. Policy implication for the "transport and communication" sector.

The analysis of the transport and communication sector made us observe a CO_2-FDI relationship characterized by positively-signed coefficients for the technique, scale and cumulative effects. Apart from the very small numbers which make these coefficients almost irrelevant from a quantitative point of view, these findings show the detrimental role FDI plays on the levels of CO_2 emission from sectoral fuel combustion. This detrimental role is also confirmed by the impact of FDI on CO_2 through GDP computed in +0.00006 Mt. of CO_2 (in natural logarithmic terms).

The implication we derive for policy decision is that investment in this sector can be considered slightly perverse or, more realistically speaking, almost neutral for the environment if the very small numbers of the coefficients are considered. As a consequence, policy views aimed at the enforcement of investment in the "transport, storage and communication" sector should not be forbidden. We have already explained in the section devoted to the concluding considerations of chapter three that the positive signs and very small numbers characterizing the coefficients might also be due to the fact that the sector under consideration is subject of long-term environmental regulation in various countries of our considered economic cooperation area. In Europe, for example, this sector has been subject of regulation since 1970, when the Directive "on the approximation of the laws of the Member States related to measures to be taken against air pollution by gases from positive-ignition engines of motor vehicles" - amended a number of times so far - was adopted (Directive 70/220/EEC). It is in this aspect where we could also find reasons to think that the sector in question is characterized by relatively important pollution efficiency. This results from certain levels of technology innovation brought in by FDI which contribute to maintain the coefficients of the induced-FDI effects on CO_2 very low.

With regard to the composition effect (this intended as the capital-labour ratio with capital represented by GCF) we observed a positive relationship with CO_2 form sectoral fuel combustion as a result of a coefficient equal to +0.0791. Similarly to what we have already said in relation to the result achieved for the manufacturing sector when this type of composition effect was analysed, our outcome shows the detrimental role played by capital accumulation for the environment and, more specifically, for the emission levels of the pollutant considered in our analysis. In fact, it highlights how the level of our considered pollutant increases in response to the growth of capital accumulation to which FDI certainly contributes. It has already been noted in the empirical part of this work that GCF consists of fixed assets, these including the construction of roads, railways and other transport infrastructures. However, a better look at the very small number characterizing the coefficient of the composition effect would induce us to slacken the consideration of the algebraic sign denoting its relationship with CO_2 and focus more on its almost quantitative irrelevance. This would make us more appropriately highlight the nearly-zero - and almost neutral - impact of the composition effect on the considered type of CO_2 whose total figure can be computed in +1.7882 Mt. of CO_2 (in natural logarithmic term) if the sample mean value of GCF is considered.

The policy implication arising from what has just been said can be based on the recognition that capital accumulation (which broadly means the production of public and private goods and services) generates a very slight negative detrimental impact on the environment. As a result, a reflection based on the occurrence of negative externalities from capital accumulation can bring us to see a solution in those operational principles of environmental economics we have already mentioned and, especially, in the implementation of environmental taxation mechanisms. This should be done while considering the limits of environmental taxation mechanisms, which are basically related to the difficulty - or even sometimes the impossibility - of adequately monetizing environmental values.

All this should become food for thought on what type of taxation policy would significantly raise a sort of environmentally-friendly capital formation activity (selective business tax-incentive, personal tax cuts, etc.). As a final consideration, however, the recognition that the composition effect plays an almost neutral role on the levels of the considered type of CO_2 emission, would also lead us to think that a policy approach aimed at limiting or denying capital accumulation might be inappropriate.

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CHAPTER V

Conclusions

5.1. The conceptual and methodological framework.

According to what has been referred in the first chapter, FDI is expected to grow - although moderately - in the next few years. This is despite the global economic fragility and policy uncertainty still characterizing the world situation. In the part of this work analysing the literature, the general concern that FDI can be harmful to the environment has been highlighted. In fact, FDI is subject of different views which perceive it as playing a positive role on the environment in some cases and a negative one in others. This considered, the main aim of this work was to investigate the relationship between FDI and the environment to understand whether and how FDI is beneficial or detrimental to the latter. By looking at views from the literature, it became important for us to contribute to a better understanding of the mentioned relationship with a further empirical effort.

From this perspective, this work represents a modest contribution to the scientific reflection on the considered issue and a useful analysis framework to support a more conscious policy-making activity of governments. In fact, whether FDI can be considered a driver for development – and, in particular, for sustainable development – depends on how it is managed by the receiving countries' governments. Their ability to implement ways of sustainable management of investment activities strictly depends on their vision of economic development and environmental conservation management, which are normally expressed in their policy and regulatory frameworks.

With the aim of attempting to address the research questions derived from the considerations above, the work was developed as follows. The first chapter focused on the definitions of FDI and the contextualization of its role in the globalization process. In addition to understanding the players and methods through which FDI occurs, this chapter identified the basic facts (qualitative and quantitative) of the FDI phenomenon and the various micro and macro impacts it generates. The second chapter examined the main literature produced on the FDI-environment issue. With specific regard to the effects FDI exerts on the environment, the analysis of the literature allowed us to identify three main thematic areas: **1)** the environmental effects of FDI flows; **2)** the competition for FDI and its effects on environmental standards; **3)** the cross-border environmental performance. Apart from the second and the third, which basically focus on the location and behavioural aspects of trans-national firms respectively, it is the first thematic area of "the environmental effects of FDI flows" where we found motivation for our work.

We have already noted in the chapter devoted to the literature analysis that this thematic area is generally perceived as one of those research grounds for which a better and more appropriate scientific understanding must be built. As reported in the chapter in argument, works in this field can be grouped into two main veins. The first vein, particularly developed between the late 1990's and the beginning of the 2000's, numbers among its major studies those works focusing on the individual analysis of each single aspect playing a role in the FDI-environment relationship (technique, scale, cumulative and composition effects). From the mid-late 2000's a new analysis approach – whose works can be grouped into the second vein – based on the contemporary consideration of the above-mentioned environmental effects of FDI (technique, scale, cumulative and composition effects) was developed. This approach matured on the basis of the particular recognition that FDI does not occur as an isolated phenomenon only affecting the environmental sphere, but it also interrelates with other linked factors (OECD, 2002[b]). However, the literature review showed the existence of a scientific effort predominantly produced in relation to the effects of liberalization on the environment and in terms of analyses of the trade-environment relationship rather than the FDI-environment one. Furthermore, in those few cases where the FDI-environment relationship is the subject of investigation, even the most recent scientific works base their analysis efforts on the consideration of aggregated values of FDI flows and polluting agents. Apart from some more recent studies**,** no significant effort appears to be made in the production of work which analyses the FDI-environment relationship from an activity sector point of view, that is while considering sectoral breakdown data.

Our view is, instead, that a more focused and detailed situation can be observed at the level of each specific activity sector. This would also help to reduce the risk that investigating the bigger picture can induce in misunderstanding and misrepresenting the actual dynamic existing in the FDI-environment relationship. Hence, we followed this methodological approach for our analyses with the expectation of producing a more appropriate investigation of the FDI-environment relationship. It is this sectoral approach of investigation which represents the original aspect of this work and brings - to some extent - some novelty in the enforcement of a vein of literature for which more should be written in an attempt to cover the knowledge gap.

For our empirical analyses, presented in chapter three, we first worked at identifying useful data and at composing a database which could enable us to carry out investigation on the level of specific activity sectors[126]. More specifically, the three activity sectors we focused on were "agriculture and fishing", "manufacturing" and "transport and communication". For each of them the FDI-environment relationship was investigated while considering some specific pollutants. CH_4 and CO_2 from the sectoral fuel combustion were both considered for the analysis of the "agriculture and fishing" sector. The investigation of the other two sectors was made on the consideration of only CO_2 from the sectoral fuel combustion.

An unbalanced panel dataset was purpose-built to contain observations for 30 OECD countries. The time span taken into consideration for the analysis of the "agriculture and fishing" sector was that between 1990 and 2005 for the examination of the CH_4-FDI relationship. The period between 1981 and 2005 was, instead, considered when the sector was analysed in terms of the relationship between the sectoral CO_2 emissions from fuel combustion and FDI. This same time span was considered for the analysis of the relationship between the CO_2

[126] We mainly referred to the OECD database where we found the only possibility of gathering FDI data at a sectoral level, although various gaps characterize their historical series. Other major international organizations' databases were also consulted for other statistics.

emission form the sectoral fuel combustion and FDI for the "manufacturing" and "transport and communication" sectors.

5.2. The evidence of our study and policy views.

Our investigations of the FDI-environment relationship provide us with evidence which has difficulty supporting that part of the literature stating that FDI generates a relevant impact - either positive or negative - on the environment. In fact, by recalling very briefly from the previous chapter the most relevant achievements of our work and focusing our attention only on those results associated to the induced-FDI cumulative effects obtained from our empirical analyses, we observe the following. When the "agriculture and fishing" sector was investigated with the aim of analysing the CH_4-FDI relationship, the coefficient of the cumulative effect was observed as equal to +0.0427 + 0.0018 *FDI*, this showing the increase of Methane emission when FDI grows by 1%. When the "agriculture and fishing" sector was analysed on the consideration of the CO_2-FDI relationship, the cumulative effect coefficient appeared characterized by -0.0848 - 0.0036 *FDI*, this showing the increase of CO_2 in response to a 1% growth of FDI. The cumulative effect coefficient for the "manufacturing" sector was indentified equal to +0.0058 + 0.0014 *FDI* which represents the scale of increase of the sectoral CO_2 from fuel combustion when FDI grows by 1%. Finally, the coefficient of the cumulative effect for the "transport and communication" sector was found equal to +0.0027 + 0.0014 *FDI*, this representing the growth of the sectoral CO_2 from fuel combustion as a result of a 1% increase of FDI[127].

[127] It was also observed how for the two cases of the "manufacturing" and "transport and communication" sectors the algebraic signs denoting the impact of FDI on the considered pollutants through GDP confirmed those achieved for the direct relationships between FDI and the considered pollutants. For the manufacturing sector (model [3]), in fact, we observed an induced-FDI cumulative effect on the sectoral CO_2 equal to +0.0051 and an impact of FDI on CO_2 through GDP equal to +0.00002 (with FDI and GDP considered at their sample mean value respectively). For the "transport and communication" sector (model [4]) we found an induced-FDI cumulative effect on the sectoral CO_2 equal to +0.0022 and an impact of FDI on the pollutant through GDP equal to +0.0006 (with FDI and GDP considered at their sample mean values). In contrast, for the case of the "agriculture and fishing" sector, the work on model [1] made us observe a cumulative effect of FDI on CH_4 equal to +0.0213 and an impact equal to -0.0003 when the FDI impact on the pollutant was assessed through GDP (with FDI and GDP considered at their sample mean values). The work on model [2], instead, did not make us observe any evidence of the FDI impact

As has been extensively highlighted in other parts of this work, the interpretation of these results would suggest the existence of a beneficial role of FDI on the environment (this intended in terms of a decrease of the levels of the considered pollutants) when the sign is negative and vice-versa. A closer look at the quantitative aspect of the above-mentioned coefficients, however, would make us more realistically appreciate a nearly-zero impact of FDI on these environmental indicators from which an almost neutral role played by FDI can be observed. This nearly-zero environmental impact of FDI would induce us to think that there is no need to make our analysed sectors subject of further environmental regulations.

As already noted in our discussion, in fact, we should not omit to consider that in the majority of OECD countries investment activities in the analysed sectors occur under a well-enforced environmental regulatory framework. This could be perceived as the driving force which has made our technique and scale effects perform as observed. As very briefly referred in the discussion for the case of the European countries, for example, these policy regulations generate a stricter environmental regime with respect to other countries. Although, as said, this can help to drive investment through a more efficient path, we also realize that this consideration is valid only up to a certain point. If the environmental policy begins to be perceived as too stringent by investors, then the potential risk that they decide to relocate their production can objectively become a natural consequence in the attempt of avoiding the loss of competitiveness. As widely commented in the second chapter of this work, the existence of a rigorous environmental policy can objectively generate the conditions typically characterizing the "pollution havens" phenomenon and the "escape" of investment.

Considering what has been said, the core for policy reflections becomes the search for an equilibrium between the need for ensuring environmental protection through the implementation of appropriate policies without impeding FDI. It is useful to remember the great importance of this policy issue due to the

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on the pollutant through GDP, since the model estimation did not produce any significant result to describe the sectoral CO_2-GDP relationship. However, an induced-FDI cumulative effect on CO_2 equal to -0.0436 was observed.

implications it has on the well-being of populations in terms of pollution, health, economic growth and income distribution.

5.3. The contribution and limitations of the study.

As already pointed out, the aim of this study to contribute originally and innovatively to the literature mainly lies in its empirical investigation of the relationship between the flow of FDI and the environment at the level of specific activity sectors, while taking into consideration the FDI flows and the pollutant agents in strict association with the economic sector investigated over time. In fact, to the best of our knowledge – apart from isolated research experiences (e.g. Ben Kheder, 2010) – the works produced so far focus too much of their attention on the macro-dimensions of these two aspects while considering the aggregated values of FDI flows and polluting agents at a national level. In our view, this represents a negative constraint in validly contributing to a proper understanding of the investigated phenomenon. Hence, our work could be seen as a step in the right direction to overcome this situation and to orient the production of works towards the search for more detailed evidence at the level of specific activity sectors. This would help in bringing about suggestions for a more appropriate policy-making process.

Nevertheless, our study suffers from some limitations. In particular, these included the existence of various gaps in the records of the international organizations we consulted to compose the database for our empirical analysis. This is particularly true in relation to the historical series of FDI flow data contained in the OECD database. A further concern of this analysis is represented by the fact that it has not been possible to investigate the FDI flow qualitatively within the considered sector. Due to the lack of data and information, we were unable to observe the modification of the pattern of FDI within the investigated sector. As highlighted in those sections of chapter three devoted to the concluding comments on the results of the empirical analyses and also in the discussion presented in chapter four, we were unable to refer whether this evidence was the result of a relocation phenomenon which pushed investment away from one sector to enter a different one or if investment moved from “dirtier” activities to “cleaner” ones while staying within the same sector.

5.4. Ideas for future research.

It is with particular reference to these two limitations where our work finds and highlights some ideas for further research. With regard to the first aspect, associated to the lack of a more complete series of FDI data, other sectors different from those here investigated could be subject of analysis through the use of the same methodology. In fact, further analysis based on more updated statistical information could be carried out while benefitting from a more powerful data structure. With regard to this, we are aware of the fact that OECD – which, as we said, is the only international organization reporting the breakdown by sector of FDI data – updated its database at the very end of 2012 so bringing the last year considered for FDI records from 2005 to 2008.

Together with this, however, we do believe that a considerable addition to the literature could derive from the second aspect we have highlighted, namely the need for investigating the qualitative side of the FDI phenomenon. In fact, an interesting point, which still does not seem to be properly addressed, is the understanding of whether the structural shift most countries experience by moving investment flow from one sector (e.g. manufacture) to another (e.g. service), or from one activity to another within the same sector, is environmentally valuable. A further call for research in this area – which, to the best of our knowledge, is still today characterized by a lack of adequate data – can surely help to produce useful evidence to deepen and attempt to complete the reflection on the issue of the environmental effect of investment and to guarantee a more appropriate support to the policy-making activity of governments.

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